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U.S. Dept. of Army

**WAR DEPARTMENT
TECHNICAL MANUAL**

**INSTRUCTION GUIDE
SOUND RANGING
PLOTING BOARD M1**

March 8, 1942

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WAR DEPARTMENT,
WASHINGTON, March 8, 1942.

INSTRUCTION GUIDE

SOUND RANGING PLOTTING BOARD M1

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*This manual supersedes TM 9-2684, August 1, 1941.

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SECTION I

GENERAL

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1. **Purpose.**—This manual is published for the information of both the using arms and services and ordnance maintenance personnel.

2. **Scope.**—This manual covers the general theory underlying the sound ranging plotting board M1, a general discussion of the instrument, complete operating instructions, a detailed description of its parts, and necessary care and adjustments. Maintenance operations described may be performed by using arms personnel.

SECTION II

DESCRIPTION AND FUNCTION

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3. **General.**—The sound ranging plotting board M1 consists mainly of a frame rigidly supported by four legs; two carriages, one with a straight base and one with a curved base; a straightedge, graduated in yards to a scale of 1/20,000, pivoting about a bracket attached to the rear of the frame, and riding on an arc-shaped rail at the front of the frame; all the necessary plotting surfaces, platens and correction charts; and, among the accessories, a waterproof cover, an accessory chest, and a packing chest.

a. The plotting surfaces are removable aluminum plates which can be clamped to the carriage. Each instrument is supplied with two straight-base plates and two curved-base plates to be used with the corresponding carriage.

b. Four straight-base and eight curved-base platens are furnished with each instrument. These platens are steel plates containing tapered holes which can be attached to the carriage to provide a means of locating and locking the carriage in position. A locating and locking mechanism attached to the frame is provided with a plunger which fits down into these holes. This mechanism can be operated from either the front or rear of the board by means of levers connected to it. (See figs. 27 and 28.)

c. The straight-base carriage can be moved back and forth across the frame on the rollers provided, while the curved-base carriage pivots about a spindle mounted in the frame. A time-difference scale, which represents the time differences multiplied by 100, is permanently attached to the arc-shaped rail extending up from the frame and contains five different scales: a degree scale and four time-difference scales for 4.0, 4.5, 5.0, and 5.5 sound-second sub-base lengths. The pivoting straightedge, known as the asymptote range arm, which rides on this scale is provided with a clamping mechanism to hold it in place over a definite reading of one of the scales when plotting.

d. Five correction charts, one temperature correction chart and four asymptote correction charts, are provided to facilitate the determination of the necessary corrections that have to be added to the time intervals. These charts are nomographs printed on white vinylite sheets (see figs. 20, 21, 33, 34, and 35).

e. The sound ranging wind corrector M1 is used to solve the wind correction equation graphically, and the wind correction in time-seconds can be read from it both in value and sign. It consists principally of a central correction scale, an azimuth scale which is free to rotate about the central disk, and the wind arm to which are fastened scales indicating the wind velocity in miles per hour.

4. Identification.—The sound ranging plotting board M1 is an instrument used in determining the terrestrial location of a sound source by plotting the data obtained from sound ranging operations. The M1 unit has been developed from the experimental T3 model.

5. Functions and limitations.—a. The sound ranging plotting board M1 is used by the operation section of sound ranging platoons of an observation battery to determine the terrestrial location of a sound source.

b. It was designed primarily to provide a quick and accurate means of plotting the data obtained by sound ranging on hostile batteries (usually medium and heavy artillery) in order to determine the location of such batteries. This is known as a sound ranging location. It is also used for adjustments of fire for gun and howitzer batteries when firing on targets of great importance. This is known as a sound ranging adjustment.

c. The board can be used in sound ranging locations or adjustments by using either the straight line microphone base or the curved-base method, employing any one of the three standard curved bases with various standard microphone sub-bases.

d. With the regular platens, locations up to 20,000 yards range can be plotted, but by use of the four straight-base platens that have been

modified, locations up to ranges of 40,000 yards can be plotted. However, the location of the longer ranges will not be as accurate as for the shorter ranges. The error for the longer ranges will be much greater than the average error for ranges under 20,000 yards, as the error increases faster than the proportionate increase in distance.

SECTION III

THEORY OF SOUND RANGING

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6. Definitions.—*a. Sound ranging.*—Sound ranging consists of receiving at a number of microphones the sound wave produced by a gun or by the explosion of a projectile, and determining the source of the sound wave by a study of the time intervals between its reception at the several microphones.

b. Sound ranging location.—The location of an enemy gun ascertained by sound ranging methods.

c. Sound ranging adjustment.—The adjustment of the fire of a friendly gun or battery by sound ranging methods.

7. Theoretical problem.—*a. General.*—(1) The discharge of a gun or the burst of a shell causes a sound wave which can be compared to the ripple set up on the water when a pebble is thrown into a still pond.

(2) Although the form of the sound wave is spherical, its intersection with the plane of the earth's surface produces a wave phenomenon similar to the ripple on water. The location of the point of origin of the sound wave can be determined if the times at which the wave reaches three or more accurately surveyed points are known.

b. Example.—(1) Thus if we suppose there are three points, M_1 , M_2 , and M_3 , all accurately surveyed, a gun discharging will cause the sound wave to reach them at times T_1 , T_2 , and T_3 , respectively. If the wave arrives first at M_1 , the point of origin of the sound wave must be nearer M_1 than M_2 by the distance the wave travels in the time $T_2 - T_1$. This distance is $V(T_2 - T_1)$, where V is the velocity of sound. Similarly, it is nearer M_1 than M_3 by the distance $V(T_3 - T_1)$. (See fig. 1.)

(2) If we now plot the positions of M_1 , M_2 , and M_3 to scale, draw arcs with M_2 and M_3 as centers, with $V(T_2 - T_1)$ and $V(T_3 - T_1)$ as radii, and pass a circle through M_1 , tangent to the arcs whose centers are M_2 and M_3 , the circle will represent the position of the sound wave

at the time it passed M_1 . The center of this circle, G , will indicate the point of origin of the sound wave.

c. Corrections.—Since a sound wave is propagated through the air, its velocity is affected by wind and other atmospheric conditions which cannot be ascertained with precision. The velocity of sound, therefore, cannot be accurately determined; however, by applying corrections for the velocity and direction of the wind, and the effect of the temperature upon the velocity of sound, the results obtained by sound ranging are of sufficient accuracy for the purpose required.

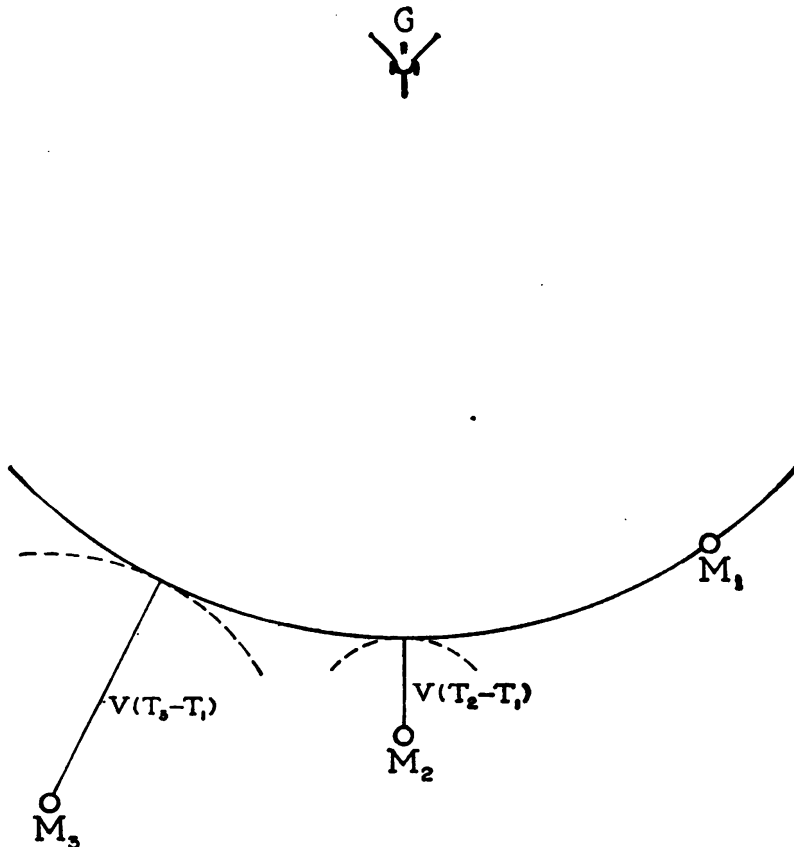


FIGURE 1.—Plotting a sound source by means of circles.

(1) *Wind correction.*—(a) The net effect of the wind is to change the times at which the sound wave will arrive at the individual microphones. The time interval will vary according to the velocity and direction of the wind. A wind correction equation has been developed giving the correction to be added to the time interval when the velocity and direction of the wind are known.

(b) For a more detailed explanation of the theory of wind correction and development of the wind equation refer to FM 6-120.

(2) *Temperature correction.*—(a) The velocity of sound in still air at 50° F. (10° C.) at an assumed constant mean humidity is considered to be 369.2 yards per second. Variations in humidity from the assumed mean have but slight effect and can be disregarded. Variations in temperature, however, have a decided effect and corrections must be applied for such variations.

(b) The velocity of sound in air increases with an increase in temperature and decreases with a decrease in temperature. Since the time intervals are inversely proportional to the velocity of sound, the correction may be applied as a percentage of the recorded time interval. Thus a temperature correction of 0.1 percent of the recorded time interval for every degree of temperature above 50° F. must be added to the recorded time interval, and for all temperatures below 50° F., must be subtracted.

(c) For a more detailed discussion of the temperature correction see FM 6-120.

d. *Position of microphones.*—(1) In actual practice it has been found that six microphones are necessary to locate a source of sound with sufficient accuracy. The microphones are connected electrically to a central station where the time of arrival of the sound at each is recorded. The six microphones are generally spaced at equal intervals, either along the arc of a circle or along a straight line.

(2) The whole line is called the *base*, and the interval between any two adjacent microphones a *sub-base*. If the microphones are along the arc of a circle, the base is called a curved base; if on a straight line, a straight base; if spaced at irregular intervals, an irregular base. The straight line joining the exterior microphones of a curved base is called the *long chord*.

8. *Theory of plotting.*—a. *General.*—The method of plotting by means of circles (par. 7), although very simple theoretically, is inconvenient in practice. If the locations are plotted to a scale of 1:20,000, the radius of the touching circle is inconveniently large and there is no simple geometrical method of finding its center. A very satisfactory method of plotting may be obtained by making use of the characteristics of the hyperbola.

b. *Hyperbola.*—(1) The hyperbola (fig. 2) is the locus of a point which moves so that the difference of its distances from two fixed points, called the foci, remains a constant. The moving point and the foci must be in the same plane. The generated curve is an open curve of two symmetrical branches, each of infinite length. In figure 2, F_1 and F_2 are the foci and XX_1 the transverse axis which is equal to the constant difference. Two straight lines, called asymptotes,

are associated with the hyperbola. The asymptotes are straight lines which intersect at the midpoint of C of the straight line joining the two foci, and become tangent to the hyperbola at infinity.

(2) In other words, if we consider only one-half of one of the branches of the hyperbola with its part of the asymptote, the curve starts at X at a distance, CX , equal to one-half the transverse axis from the asymptote and gradually approaches the asymptote until the two meet at an infinite distance from the point C . It is readily seen, therefore, that the farther we go from C , the closer together the two corresponding points, P on the curve and P_1 on the asymptote, come.

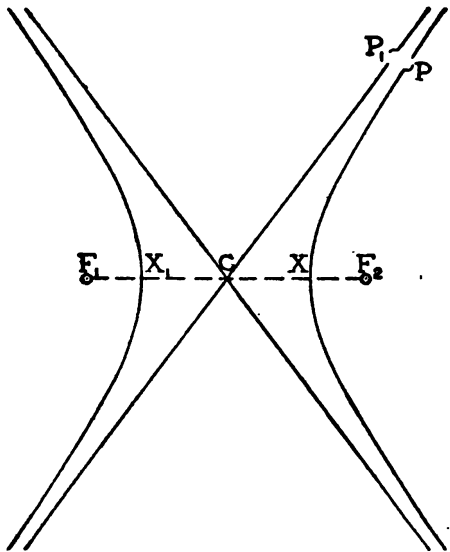


FIGURE 2.—Hyperbola and asymptotes.

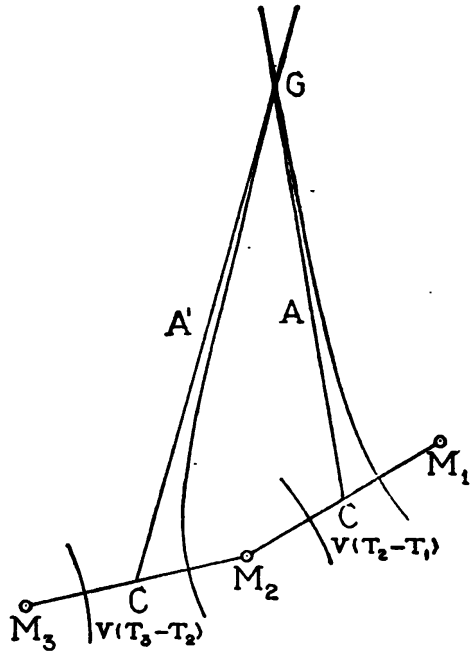


FIGURE 3.—Hyperbolic plotting.

a. Hyperbolic plotting.—(1) Referring to the problem given in paragraph 7, the sound arrives in order at M_1 , M_2 , and M_3 at times T_1 , T_2 , and T_3 , respectively. Plot, as before, M_1 , M_2 and M_3 to scale (fig. 3). If a branch of a hyperbola is now constructed having M_1 and M_2 as its foci and $V(T_2 - T_1)$ as the transverse axis, the curve will pass through the sound source. A sound source at any point on this curve would fulfill the conditions that the time interval would be $T_2 - T_1$, since the transverse axis was made equal to $V(T_2 - T_1)$. In a similar manner construct a hyperbola having M_2 and M_3 as its foci and $V(T_3 - T_2)$ as the transverse axis. This curve will also pass through the sound source and the intersection of the two curves must be the location of the source of the sound.

(2) If more stations are available, other hyperbolae could be constructed in a similar manner and the location of the source of the sound taken at the intersection of all the hyperbolae. In actual practice, three or more hyperbolae seldom intersect at a point but will form a small polygon of error. The center of gravity of this figure is taken as the location of the sound source. The hyperbola is not an easy curve to construct, and since each sound ranging determination would require the construction of five hyperbolae, the method is too tedious to be practicable.

d. Asymptotic plotting.—(1) *General.*—The sound ranging plotting board M1 provides for the plotting of *asymptotes* instead of hyperbolae. Since the distance to the sound source is usually greater than four times the length of the sub-base, the errors introduced by this approximation can either be corrected for or neglected on long ranges. In figure 3, the position of the sound source is plotted by both the asymptotes and the hyperbolae. Note the small error of location; this error can be calculated and corrections made to eliminate it.

(2) *Time-difference scale.*—(a) To simplify plotting, a time-difference scale has been constructed and fastened to the arc-shaped rail on the frame of the plotting board. The graduations of these scales represent the measured time interval, t , and are so arranged that when a straightedge is laid from the midpoint C of a sub-base to the graduation representing a measured time interval, it will make the proper angle θ with the perpendicular bisector CN .

(b) In figure 4, the time interval t having been determined as 2.00 seconds, a straightedge is laid from C to the 2.00-second graduation and the asymptote drawn without any computation of the angle θ . In a normal sound ranging board there are five sub-bases and a location is determined by the five asymptotes intersecting at a point or forming a polygon of error. The coordinates of the location are determined from the grid on the plotting board.

e Corrections.—The results obtained by plotting on the sound ranging plotting board M1, according to the theory outlined above, would be true under ideal conditions. However, as such conditions never exist, corrections have to be applied for each time reading to take into consideration the effects of wind and temperature, and the plotting of the asymptotes instead of the hyperbolae themselves.

(1) *Wind correction.*—(a) A mechanical device known as the sound ranging wind corrector M1 (fig. 31) is used to solve the wind equation mechanically.

(b) The wind correction equation has been plotted for 4.0, 4.5, 5.0, and 5.5 sound-second sub-bases in a set of curves so that the correction

may be read for a wind of any velocity and direction with respect to the sub-base. For a more detailed explanation and a reproduction of these curves refer to FM 6-120.

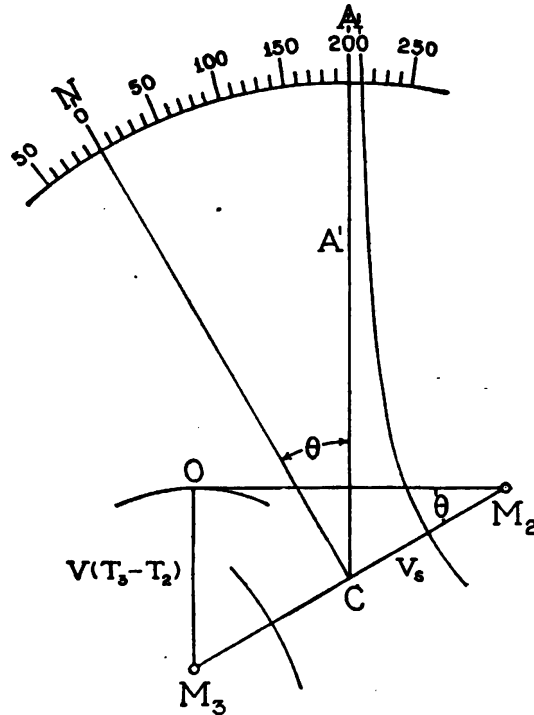


FIGURE 4.—Asymptotic plotting.

(2) *Temperature correction.*—(a) The time scales on the plotting board and the length of the sub-bases in sound-seconds are based upon a velocity of sound of 369.2 yards per second. The temperature correction chart (fig. 20) has been plotted so that the correction for any temperature may be quickly ascertained. Corrections for temperatures below 50° F. take an opposite sign from the time difference, while for temperatures above 50° F., the corrections take the same sign as the time difference.

(b) The time intervals as read from the film of the time difference measuring apparatus must be increased or decreased according to the correction ascertained from the temperature chart.

(3) *Asymptote corrections.*—(a) Since the asymptotes of the hyperbolae are used in plotting instead of the hyperbolae themselves, corrections must be applied so as to make the asymptotes intersect at the point where the hyperbolae would normally intersect. An asymptote correction is therefore applied in the course of the plotting procedure.

(b) This correction always tends to increase the angle θ ; the correction is therefore added to the uncorrected time difference so as to increase it numerically, regardless of the algebraic sign.

(c) From the asymptote correction equation (FM 6-120) it will be seen that the correction is a function of the length of the sub-base. A different correction chart must therefore be made up for each standard length sub-base. This is another reason for having a standard set of sub-base lengths instead of having a different length sub-base for each position.

(d) Correction charts (fig. 21) for the standard bases of 4.0, 4.5, 5.0, and 5.5 seconds are included in the equipment. Corrections for each time interval may be read from the chart, provided the approximate ranges to the gun are known. This range is obtained by first making a rough plot with uncorrected time intervals and scaling the distance from the rough location to the midpoint of the sub-base in question.

SECTION IV

OPERATION

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9. Operating procedure.—The procedure in the operation of the sound ranging plotting board M1 is as follows:

a. Setting up board.—(1) Remove the frame, legs, and brace from the packing chest. Set up the legs and place the brace over the legs so that each leg fits through the corresponding hole in the brace. Then place the frame on the legs so that each leg fits into the respective hole in the under side of the frame. Fasten the frame to the legs by tightening the four bolts (BCAX1EC, sec. J-J, fig. 12) contained in the frame. Raise the brace assembly to approximately 15 inches above the flanges and clamp it in position by means of the thumbscrews provided.

(2) To mount one of the carriages on the frame, it is necessary to drop the bracket (D25753, fig. 10) back out of position. This can be done by unscrewing the two bolts (A40258, sec. C-C, fig. 10).

(3) If the straight-base system is used, the straight-base carriage, with the platen corresponding to the length of the microphone sub-base attached, should be mounted on the frame so that it will ride along the guide rail provided.

(4) If the curved-base system is used, the spindle should be mounted in the frame in the position corresponding to the radius being used. The curved-base carriage should be placed over the frame so that the ball bearing on the under side of the carriage will engage the spindle in the proper position, the hole nearest to the bracket being for the 25-second radius. The corresponding platen should be attached to the carriage before it is placed on the frame.

(5) After the proper carriage has been mounted, the plotting plate should be clamped in place and the bracket returned to its operating position and fastened securely.

(6) To assemble the range arm, move to the right-hand end (in reference to the arm setter) of the time-difference scale. Then place the arm bearing over its pivot on the bracket. Before attempting to slide the arm over the rail, be sure that the spring (fig. 27) between the arm support and the clamping lever is centered in the cup on the lever, and that the clamping shoe is in a vertical position. Press the clamping lever, move the arm support over the curved rail, and release the lever. The construction of the arm and bracket prevents assembling the arm from the left-hand end and limits the motion of the arm.

b. Plotting grid.—(1) After the board has been set up according to the system being used, the draftsman lays out the grid on the aluminum plotting plate, using the coordinates of the microphone as control points and checking by the azimuth of the long chord. If the position is temporary, the grid should be put on with a pencil but if the position is more or less permanent the grid should be inked.

(2) Knowing the coordinates of the midpoints C_1 , C_3 , and C_5 , (fig. 5), one of the computers should compute the ranges from each to the corners of a square 10,000 yards on a side, or to the corners of a rectangle with sides as long as practicable, the center of the square or rectangle to be approximately in the center of the board and to represent the probable center of enemy artillery activity. From each midpoint, the draftsman should strike arcs with the computed radii by means of the range arm and vernier attachment. The intersections of the corresponding arcs will determine the corners of the square or rectangle on the plotting surface. The draftsman should then complete the square or rectangle, scale the 1,000-yard grids along each side, and complete the drawing of the grid.

(3) The plotting can be done either directly on the aluminum plotting plate or on a piece of vellum attached to the plate by means of masking tape. The vellum is used so that a permanent record can be kept and reproductions can be made for future reference. The

vellum also serves to preserve the plotting surface of the board from erosion caused by frequent erasings.

c. Rough plot.—(1) *Preliminary.*—The chief of section announces the temperature and the velocity and azimuth of the wind when he receives a meteorological message, and the computers concerned note these conditions. These conditions remain in force until a new meteorological message is received.

(2) *Computation.*—As the oscillogram reader announces the time of the breaks, a computer records them on the form provided and computes the time intervals by subtracting the reading for M_1 from that for M_2 and so on. If the time reading for M_2 is greater than that for M_1 , the time interval is positive; if the time reading for M_1 is greater than M_2 , the interval is negative and so on.

(3) *Plotting uncorrected time intervals.*—The arm setter then lays off the uncorrected time intervals on the time-difference scale and the draftsman draws the asymptotes by the following method:

(a) The front locking lever (fig. 27) is raised by the arm setter, releasing the locating mechanism, and the carriage is moved or rotated until the plunger in the locating mechanism engages the hole in the platen corresponding to the midpoint between stations 1 and 2. The lever is then lowered, locking the carriage in position.

(b) The arm setter then sets off the time difference for that point by rotating the range arm until the wire index in the arm coincides with the required reading on the time-difference scale. Before rotating the arm, the clamping lever must be compressed in order to release the arm from the rail. After the arm is set to the required reading the lever is released, clamping the arm in position.

(c) The draftsman then draws the asymptote along the beveled edge of the range arm.

(d) This procedure is repeated for each point for which there is a time difference. Frequently, in practice, readings will not be obtained on all six microphones, consequently there may be as few as three asymptotes instead of five. The intersection of the asymptotes will indicate the plotted position of the sound source.

(e) This plot, however, will be an uncorrected plot of the true position. A correction must be determined due to the velocity and angle of the wind. A temperature correction and asymptote correction must also be determined and the algebraic sum of these three corrections added to each time interval.

d. Corrections.—(1) *General.*—One computer determines the wind correction and asymptote correction while the other computer determines the temperature correction.

(2) *Wind correction.*—(a) The wind correction may be solved mechanically by use of the wind corrector M1 (fig. 22). The base markers are set to the azimuths of the respective sub-bases, and the sub-base is oriented by turning the correction disk until the index on the disk appears opposite the index on the proper sub-base marker. The wind arm is then rotated and set to the azimuth of the wind direction.

(b) The wind correction in time-seconds is read on the correction scale opposite the wind velocity shown on the wind arm. The algebraic sign of the correction is indicated on the disk and conforms to the convention adopted on the plotting-board time-difference scales; that is, that the time difference for any sub-base is positive if the sound wave reaches M_1 before M_2 , M_2 before M_3 , and so on. The sign of the correction is true only if the azimuth of the sub-base is read from M_2 to M_1 , M_3 to M_2 , etc.

(c) Care must be exercised to see that the scale corresponding to the sub-base length being used is attached to the wind arm so that it reads from the center of the disk outward.

(3) *Temperature corrections.*—The temperature correction for each time interval can be determined by means of the temperature correction chart (fig. 20). For temperatures above 50° F., the correction takes the same sign as the time interval and vice versa.

(4) *Asymptote correction.*—(a) In order to determine the asymptote correction, the computer must refer to the correction chart corresponding to the sub-base length being used. He must also have a record of the range ascertained from the rough plot.

(b) By placing a straightedge along the two variables (time interval and range) the asymptote correction for each time interval can be determined. The sign of the correction will always be the same as the sign of the time interval.

e. *True plot.*—(1) After the corrected time difference for each mid-point has been determined and recorded on the form provided, the form is turned over to the draftsman who makes a corrected plot following the same procedure as outlined for the rough plot. The intersection of the asymptotes will indicate the plotted position of the sound source.

(2) In all probability the five asymptotes will not intersect in a point, but the intersections will form a polygon known as the polygon of error. (See fig. 6.) The location is assumed to be at the center of gravity of this weightless figure. Until the plotters can select this point by inspection, the coordinates of the intersections may be read and the average taken.

10. Sound ranging location.—The location of an enemy gun or battery by sound ranging methods is known as a sound ranging location. The plotting board M1 was designed primarily for this purpose.

a. The plotting procedure is the same as outlined in the preceding paragraph. The form on which all the information is recorded, including the *X* and *Y* coordinates of the rough and corrected plots, is filed away with the vellum for future reference.

b. The coordinates of all the locations of the target concerned are averaged and the target assumed to be located at the average coordinates.

11. Sound ranging adjustment.—A sound ranging adjustment is the adjustment of the fire of a friendly gun or battery by locating the position of the shell bursts in relation to the gun-target line.

a. This method of fire adjustment is used only on targets of great importance. The position of the target must be known in advance for any degree of accuracy in plotting the location of the bursts.

b. The plotting procedure is as follows:

(1) The draftsman may plot the gun position, target, and gun-target line. He may also read the azimuth of the gun-target line and check this with the master topographer prior to the firing.

(2) As each group of shots is fired, the coordinates of the group are averaged and the center of impact plotted and announced.

12. Test problem.—The following problem may be used to familiarize the operators with the instrument and to act as a test of their accuracy in operating it.

a. The coordinates of the midpoints are as follows:

		<i>X</i>	<i>Y</i>
C_1	=	79,395.0	49,110.0
C_2	=	80,132.0	50,599.0
C_3	=	80,869.0	52,088.0
C_4	=	81,606.0	53,577.0
C_5	=	82,343.0	55,066.0

b. Lay out the grid on the aluminum plotting surface as explained in paragraph 9*b*(2).

c. Given the time readings:

Microphone 1	8.772
2	5.795
3	3.330
4	1.542
5	0.660
6	0.770

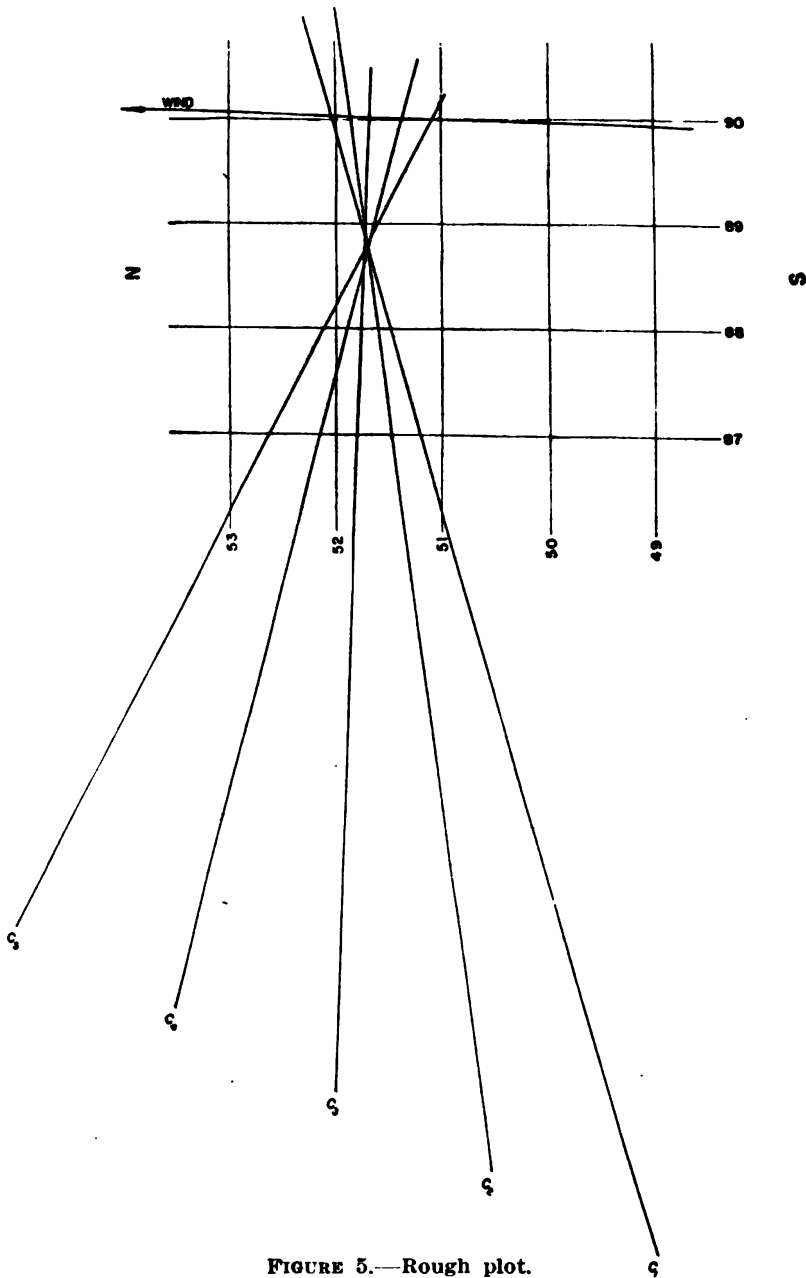


FIGURE 5.—Rough plot.

Determine the time intervals and make a rough plot to determine the approximate location, using the 'straight-base system with a 4.5-second sub-base. The ranges from the rough plot (fig. 5) should be as follows:

- | | |
|---|-------------|
| 1 | 9,800 yards |
| 2 | 8,800 yards |
| 3 | 8,000 yards |
| 4 | 7,500 yards |
| 5 | 7,300 yards |

d. The temperature is 65° F.; wind 5 mph, azimuth 2.6°. Determine the corrections for temperature, wind, and asymptote for each time interval and add the sum of the corrections to each time interval to find the corrected time interval. The corrected time intervals should be—

1	−3.053
2	−2.537
3	−1.849
4	−0.926
5	+0.086

e. Now plot a corrected plot following the operating procedure outlined to determine the true location of the enemy gun. The polygon of error should fall within the square bounded by *Y*-grid lines 88 and 89, and *X*-grid lines 51 and 52 (fig. 6). Averaging the coordinates of the 10 intersections, the coordinates of the center of gravity of the polygon of error should be:

$$X = 88,565.0 \text{ yards}$$

$$Y = 51,780.0 \text{ yards}$$

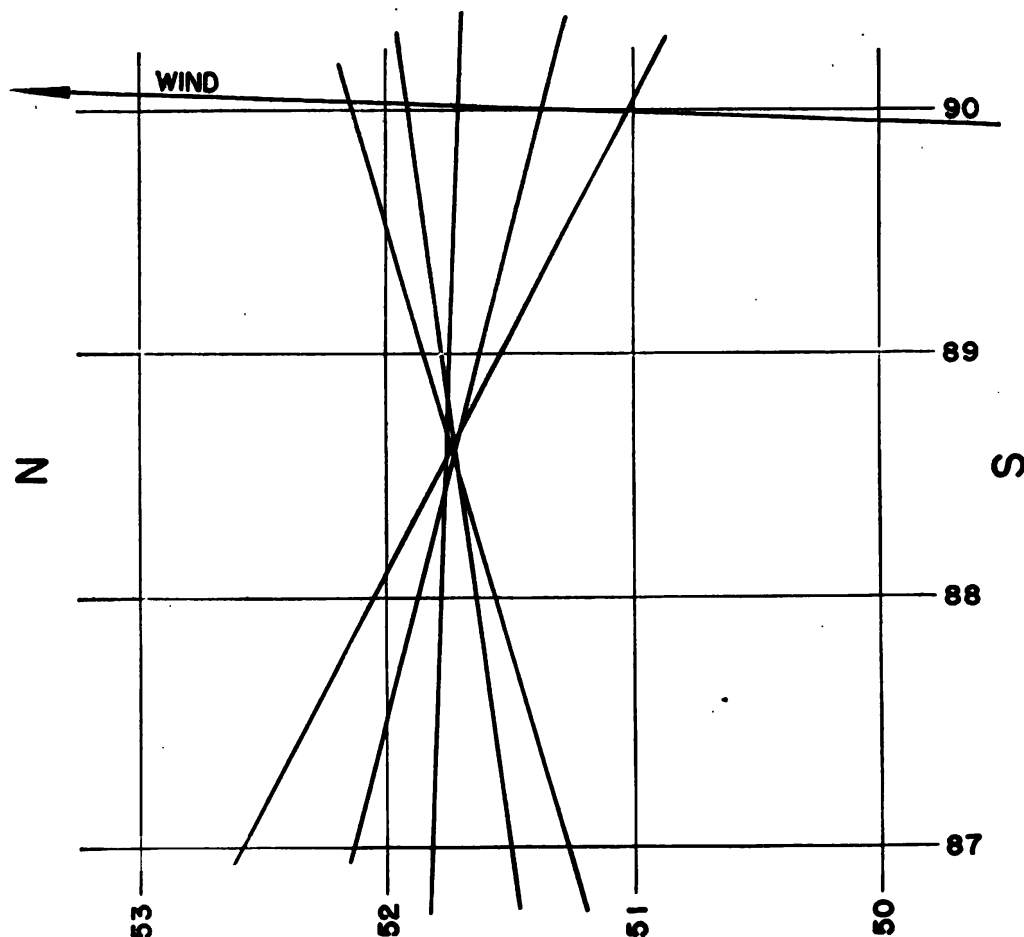


FIGURE 6.—Corrected plot.

SECTION V

DESCRIPTION OF MAJOR UNITS

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13. General.—The major units of the sound ranging plotting board M1 are the frame (figs. 9 and 25), the carriages (figs. 13 and 15) to which are attached the plotting surfaces and platens, and the asymptote range arm (figs. 17 and 23).

a. The time-difference scale represents the time differences multiplied by 100 and is permanently fastened to the frame; a locating and locking mechanism is also attached to the frame. The frame is supported by four legs that are braced to provide stability.

b. The range arm is pivoted to a bracket and supported by the arc-shaped rail of the frame. The arm is provided with a clamping mechanism operated by means of a lever.

c. There are two carriages, a curved-base carriage and a straight-base carriage. The carriages are provided with rollers which support them and allow free movement upon the frame in certain definite directions.

d. Platens are furnished with the instrument and are fastened to the carriage, to be used in conjunction with the locating mechanism. Four platens are provided with the straight-base carriage and eight with the curved-base carriage.

14. Frame.—The frame (figs. 9 and 25) supports the carriages on tracks, retains the time-difference scale in a dovetailed groove in its arc-shaped rail, and provides support for the pivot bracket and the locating and locking mechanism.

a. (1) The four legs which support the frame fit into holes in the under side of the frame and are secured by means of the bolts (BCAX1EC, sec. J-J, fig. 12). A steel bushing (A40290) is pinned in the boss to receive the bolt.

(2) A welded brace is provided to make the legs as rigid as possible. The brace fits over the legs and can be clamped securely to each leg by means of the thumbscrews provided.

(3) A flange is screwed to the bottom of each leg to provide a means of securing the instrument to the floor for a permanent installation and to afford better support when set up in the field.

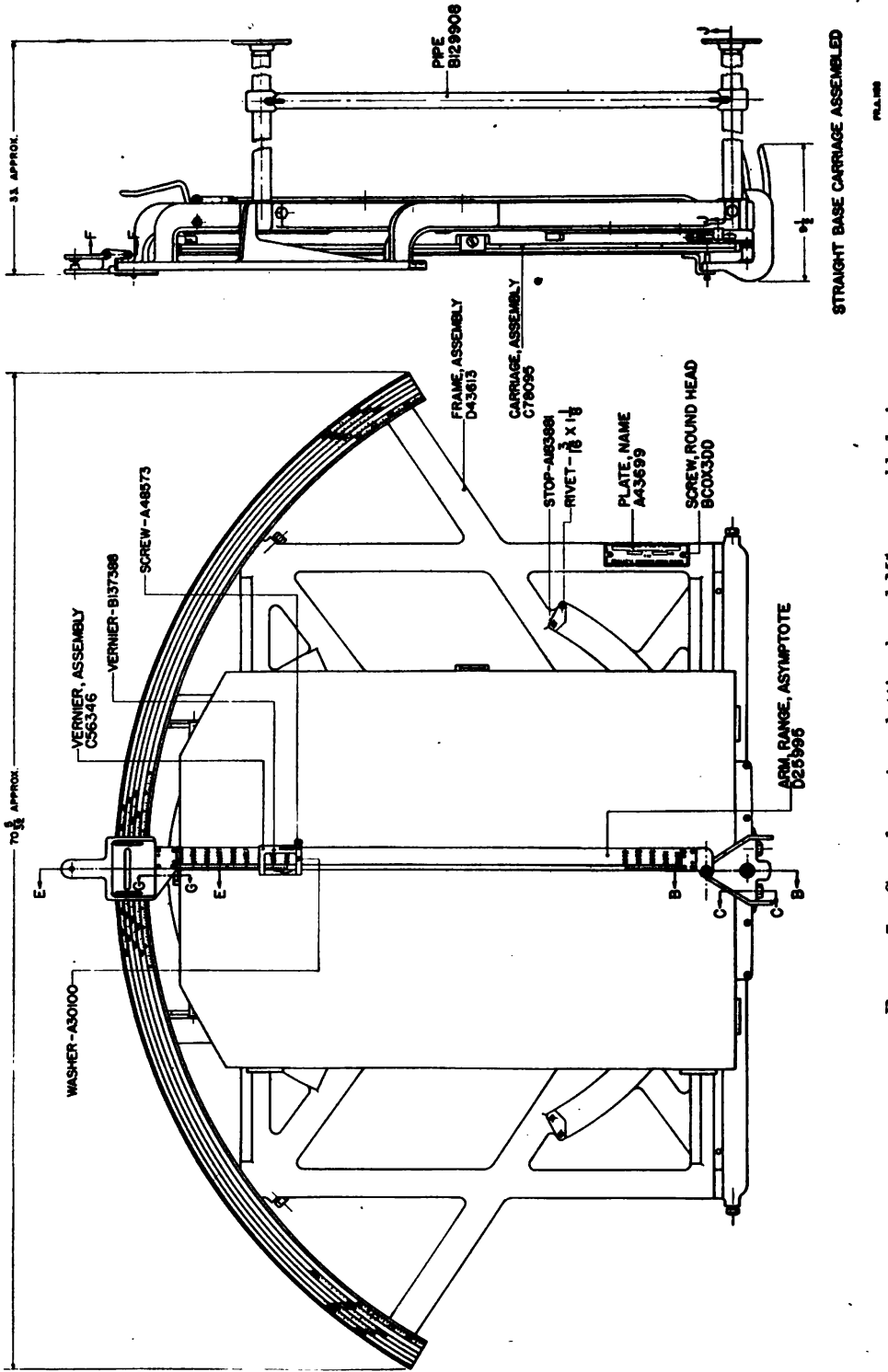


FIGURE 7.—Sound ranging plotting board M1, assembled views.

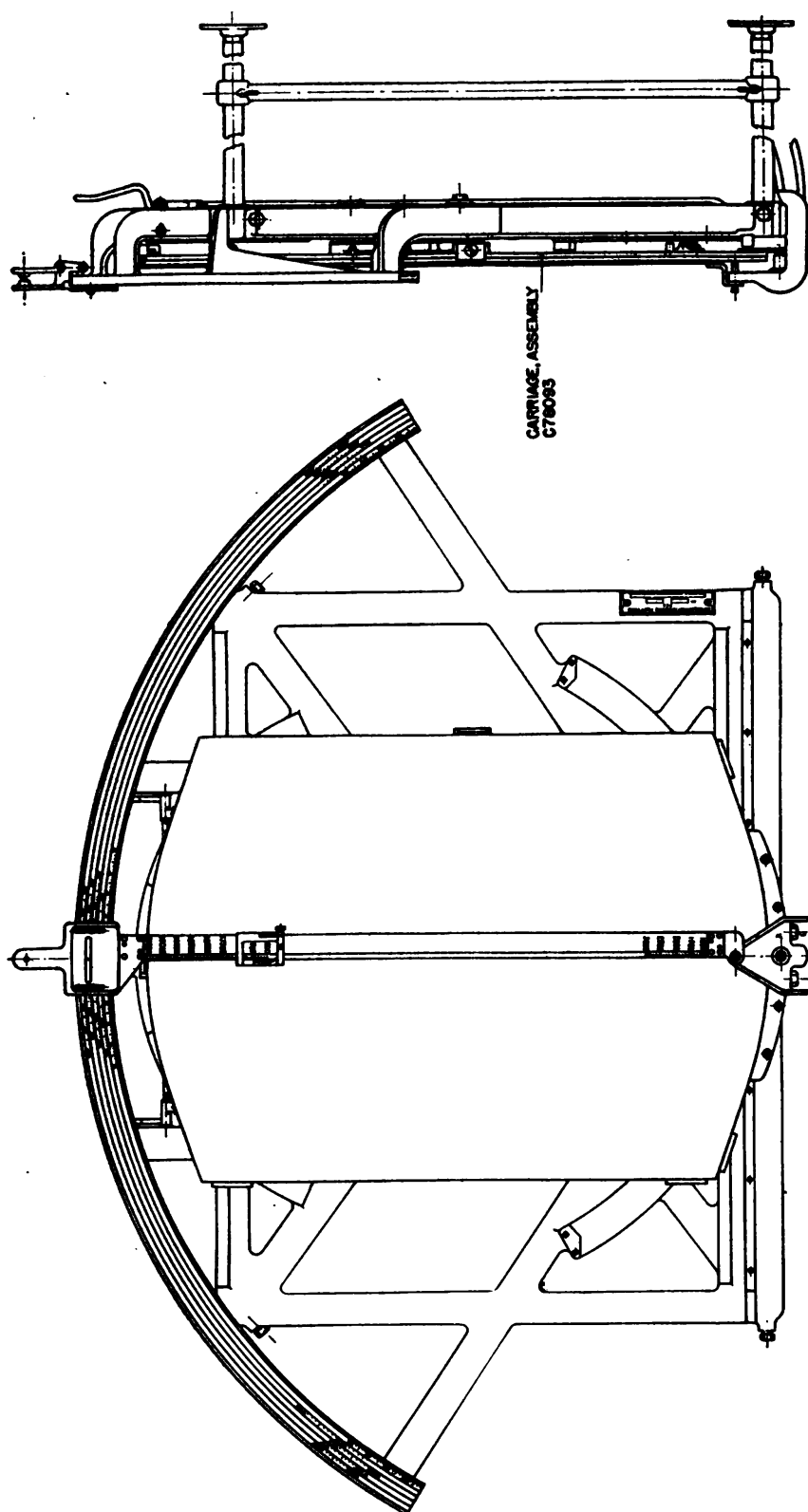


FIGURE 8.—Sound ranging plotting board M1, assembled views.

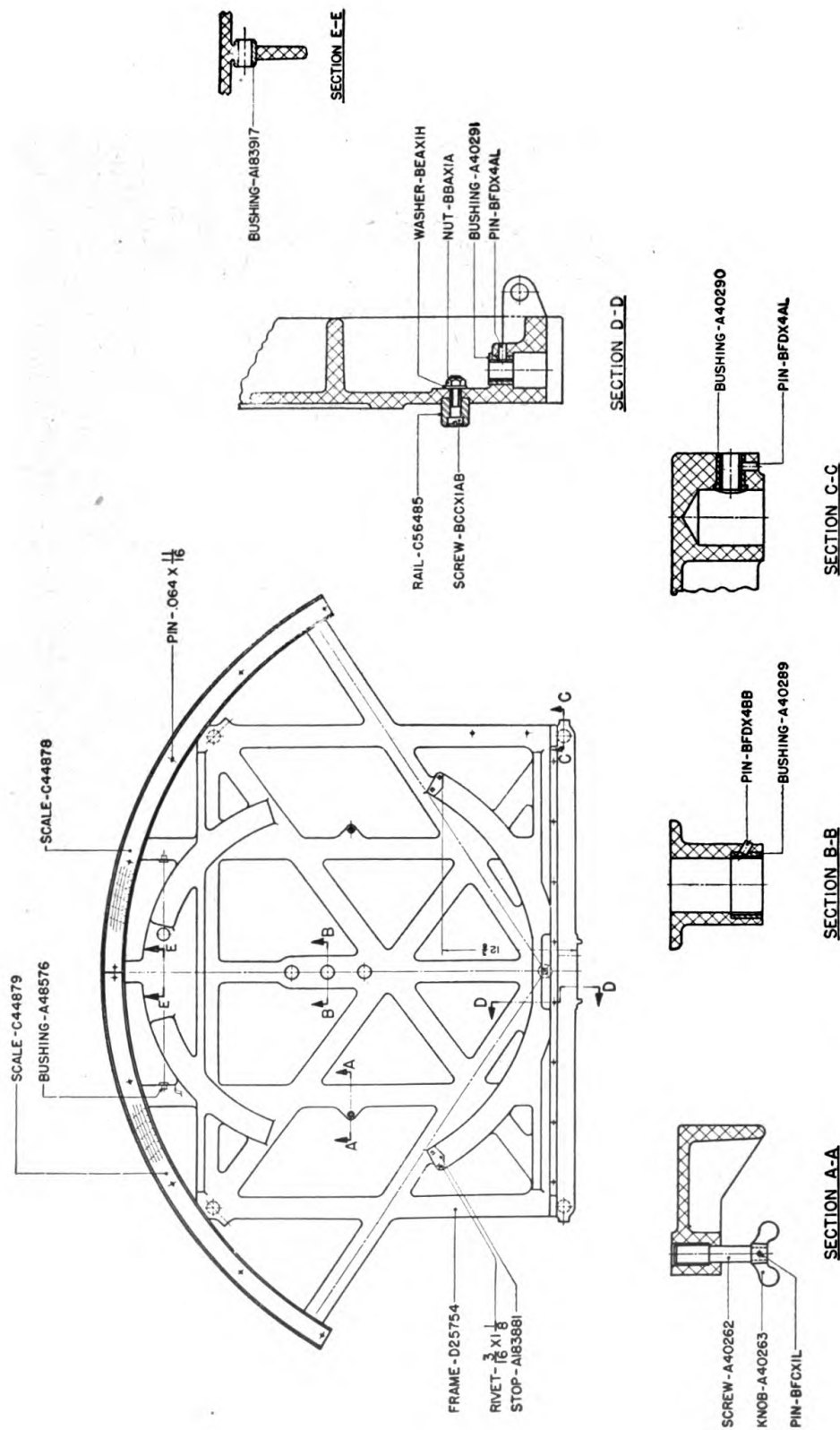


Figure 9.—Sound ranging plotting board M1, frame assembly.

b. The rail (C56485) fits into a groove in the top surface of the frame and is fastened by eight screws (BCCX1AB) and nuts (BBAX1A, sec. D-D, fig. 9). The rail acts as a guide for the straight-base carriage.

c. Two screws (A40262) are retained in the frame, one on each side, to furnish a means of securing the carriage when moving the instrument (sec. A-A).

d. The spindle (A40269, fig. 16) provides a pivot for the curved-base carriage and can be screwed into any one of three internal bearings of the frame. A threaded steel bushing (A40289) is pinned in each bearing to receive the spindle.

e. (1) The time-difference scale consists of two segments; each segment covers an arc of 60° . The scale fits into a dovetailed groove in the arc-shaped rail of the frame and is permanently secured by rivets.

(2) The scale has five different scales engraved on it, a degree scale and four time-difference scales, one each for the 4.0, 4.5, 5.0, and 5.5 sound-second sub-base lengths.

(3) The time-difference scales are graduated into hundredths of a second spaces and numbered every 10 spaces, starting with zero at the center of the arc and reading in both directions.

(4) The degree scale is graduated into 10-minute divisions and numbered every degree (every six divisions) from 0 to 59, starting with zero at the center of the arc and reading in both directions. The degree scale is used for orienting the grid and for irregular base plotting.

f. (1) The bracket (D25753), containing the carriage locating mechanism, fits in between the two lugs extending from the rear of the frame and is attached to the frame by means of the hinge pin (A40257, sec. A-A-A, fig. 11) and the two bolts (A40258, sec. C-C, fig. 10).

(2) The bolts can be unscrewed and the bracket dropped back in order to insert the carriages. The cotter pins inserted in the bolts prevent the bolts from falling out of the bracket when it is swung back.

(3) The threaded bushings (A40291) are pinned in the frame to receive the bolts.

g. The locating mechanism consists mainly of the plunger (A43697), stud (A40253), link (A40254), washer (A36038), spring (A40255), and lever (B129907).

(1) The stud is driven into the link and riveted to the plunger, and is fastened securely to the link by means of a pin which in turn is secured by a cotter pin.

(2) The bottom of the link is secured to the lever which pivots about the hinge pin (A40257). When the lever is pulled back it pivots about the hinge, raising the link which in turn raises the plunger out of the hole in the platen.

(3) After the carriage is rotated or slid to the desired position, the lever is released and the spring forces the lever back in position, thereby dropping the plunger down into the corresponding hole in the platen. The bushing (A40251) is inserted in the bracket to act as a guide for the plunger.

h. Another lever (C56347, fig. 11) is attached to the mechanism by a series of rods, yokes, and clamps so that the mechanism can be operated from the front of the board (by the arm setter) leaving the draftsman free to plot.

(1) The lever is welded to the clamp assemblies (A48577A and B) which are clamped to the rod (A48580) by means of thumbscrews. The rod is supported by the ribs of the frame and is retained at each end by a washer and pin.

(2) The rod (A48579) is connected to the cross rod by means of the arm (A48575) and is pinned to the crank (B135524) by means of the yoke (EEAX1C). The crank is pinned and keyed to the end of the hinge pin (A40257).

(3) Movement of the lever (C56347) transmits motion to the crank (B135524), turning the hinge pin (A40257) which in turn operates the other lever. When the lever (C56347) is down, the plunger is in the hole in the platen. Raising the lever raises the plunger; lowering the lever lowers the plunger.

15. Carriages.—*a. General.*—There are two carriages to each plotting board, a straight-base carriage and a curved-base carriage. The straight-base carriage is used when the microphone stations are located in a straight line, and the curved-base carriage is used when they are located in an arc.

b. Straight-base carriage.—The carriage consists of the plate (D25993), which supports the plotting plate (C56568), the platens, and the rollers that are attached to the under side of plate (D25993). (See figs. 13 and 14.)

(1) *Vertical rollers.*—(*a*) Six vertical rollers are attached to the plate, three at the front and three at the rear to provide support for the carriage and a means of moving the carriage along the track which is part of the frame.

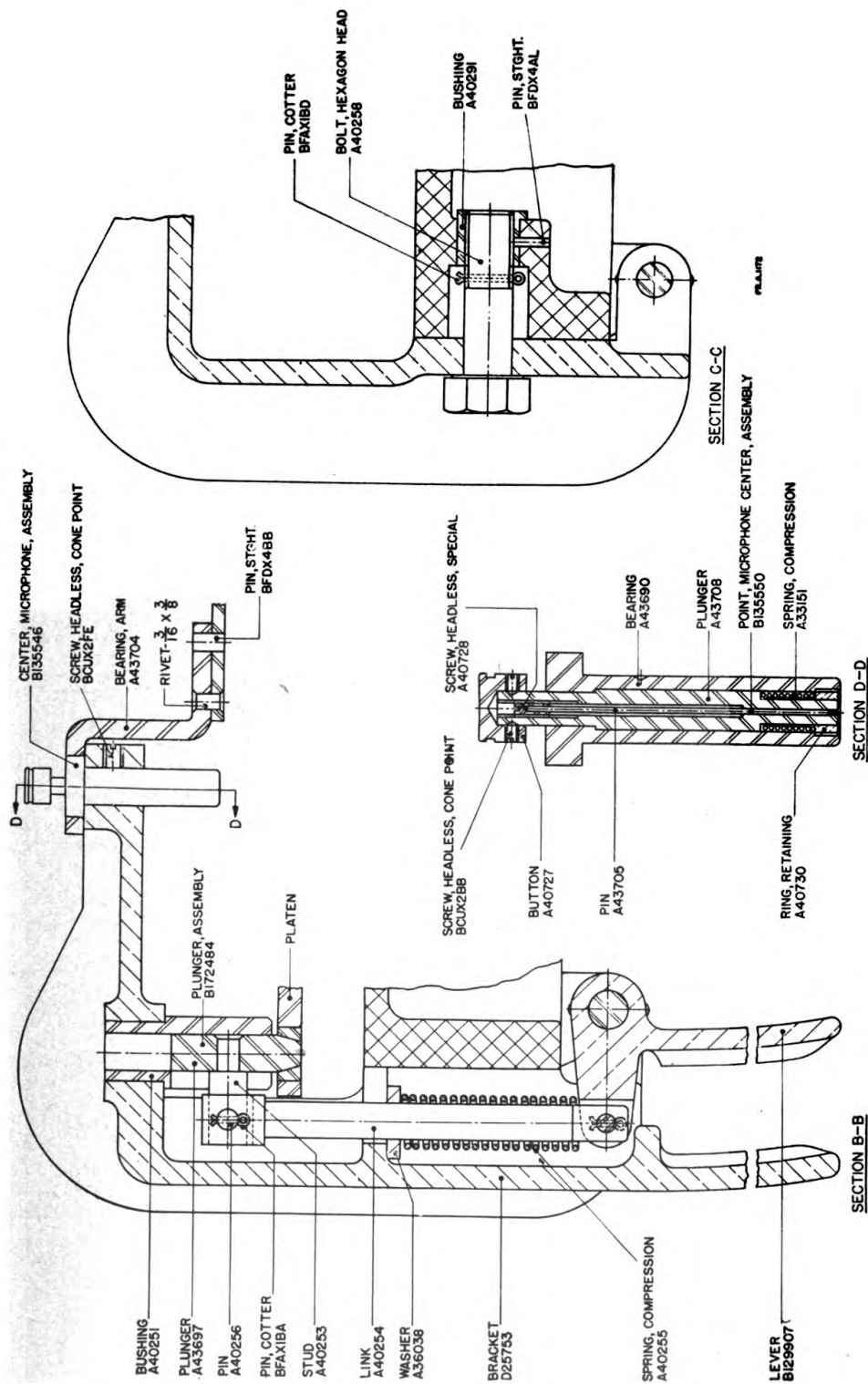
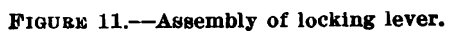


FIGURE 10.—Sound ranging plotting board M1, sectional views.



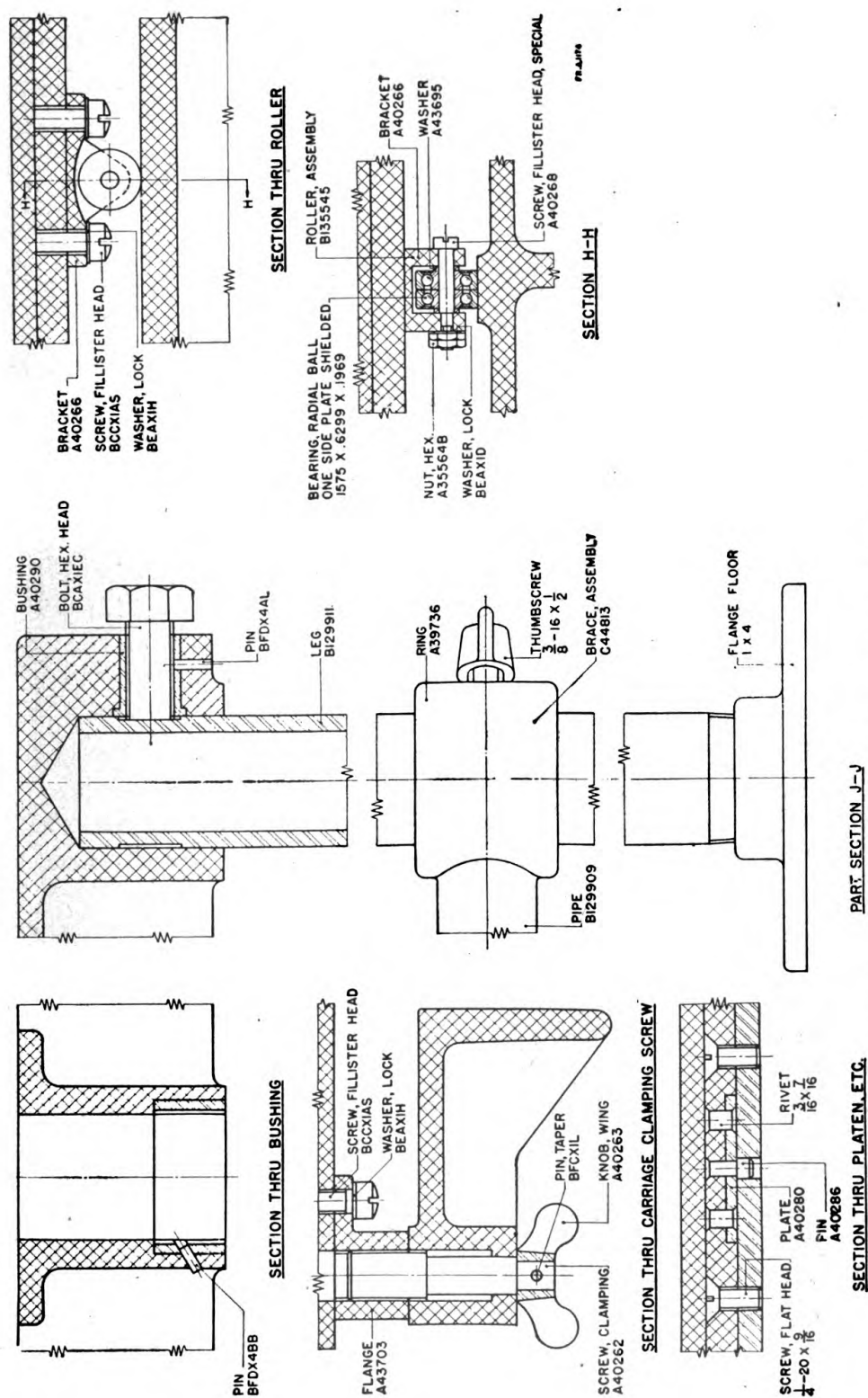


FIGURE 12.—Sound ranging plotting board M1, sectional view.

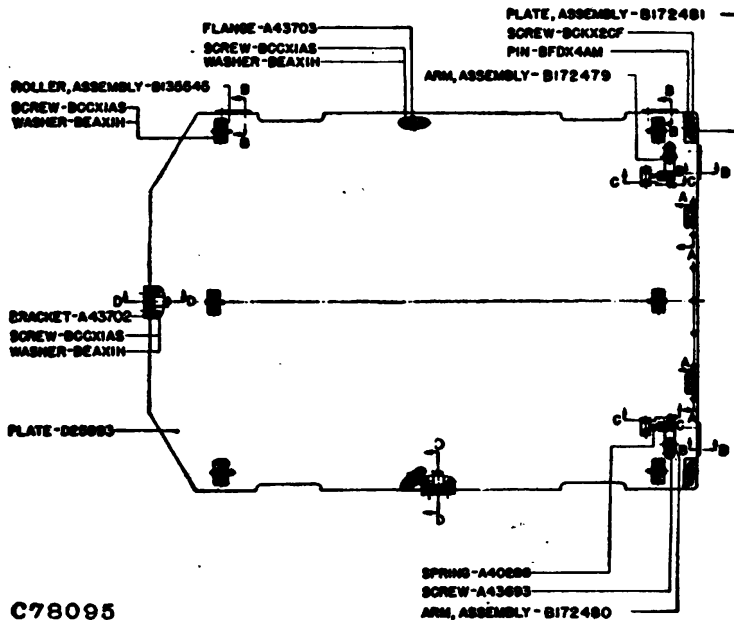


FIGURE 13.—Straight-base carriage assembly.

(b) These rollers are radial ball bearings (sec. H-H, fig. 12) which are supported in the brackets (A40266). The brackets are in turn fastened to the plate (D25993) by two fillister head screws (BCCX1AS).

(2) *Horizontal rollers.*—(a) Two sets of horizontal rollers are attached at the rear of the carriage to guide the motion of the board. These rollers are also radial ball bearings (sec. A-A-A-A, fig. 14). The bearings are retained on the plates (A43696) by special screws (A43693) and the plates are fastened securely to the carriage by means of two screws and two pins.

(b) The bearings on the inside of the rail are supported in the arms (A43691 and A43692) which are free to pivot about the screws (A43693) by which they are fastened to the carriage.

(c) The spring (A40288) bears against the block (A43694) and exerts enough pressure against the arm to insure constant contact between the roller and the rail. This will prevent any wobbly motion of the carriage as the bearings and rail wear.

(3) *Platens.*—(a) Four platens (fig. 30) are furnished with the straight-base carriage, one each for sub-base lengths of 4.0, 4.5, 5.0, and 5.5 seconds, respectively. Each platen contains seven tapered locating holes accurately located in a straight line to agree with the midpoints of the corresponding sub-base length of the microphone stations.

(b) The two outside holes may be plugged up by removable plugs when the board is to be used to ascertain sound sources with ranges

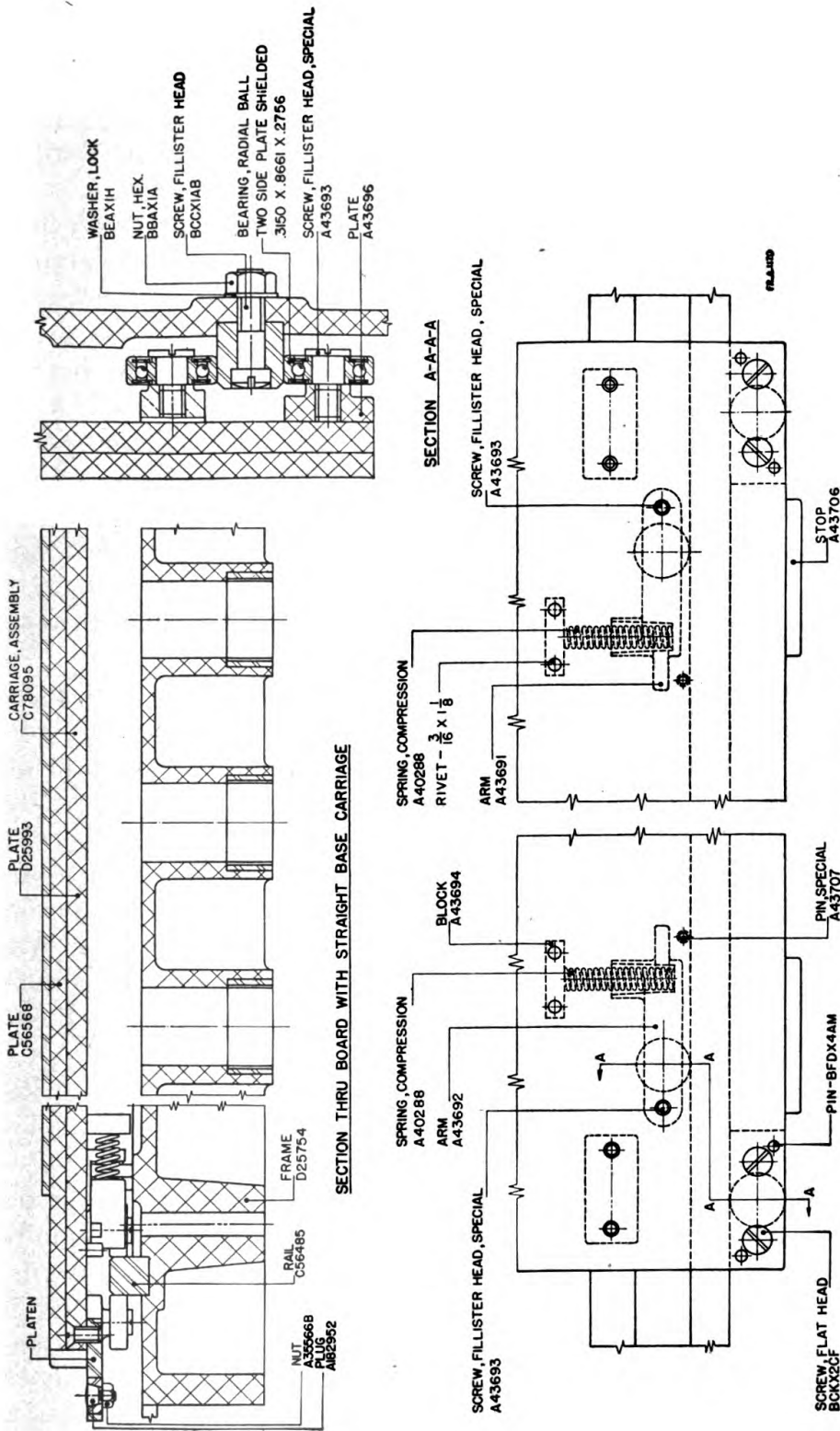


FIGURE 14.—Sound ranging plotting board M1, sectional views.

over 20,000 yards. These plugs fit into the holes and are retained by nuts and washers.

(c) The two holes adjacent to the center hole are plugged up when the board is to be used for ranges under 20,000 yards.

(d) The platens are located with respect to the under side of the carriage by means of dowel pins and fastened securely by flathead screws.

(4) *Grid plate.*—(a) The grid plate (C56568) is not fastened to the supporting plate (D25993) but is clamped in place by clamping assemblies that are fastened to the side and end of the carriage. (See figs. 13 and 19.)

(b) The clamping plate (A43698) is secured to the bracket (A43702) which is screwed to the under side of the carriage. A felt pad (A43701) is riveted to the clamp to prevent wearing the rim of the plotting plate.

(c) A cotter pin is inserted in the flathead screw (A43700) so that the screw can be loosened just enough to unclamp the plate. Two special pins (A40731) are riveted to the clamp to prevent snapping it when tightening the screw. Two stops (A43706) are fastened opposite to each of the clamping assemblies.

(5) *Flanges.*—Two flanges (A43703) are screwed to the under side of the carriage, one on each side to receive the clamping screw (A40262). (See fig. 12.) These are furnished to provide a means of clamping the carriage in position when transporting the instrument.

c. *Curved-base carriage.*—The curved-base carriage differs from the straight-base carriage in that the plates are curved at the ends and mounted on a center to provide for rotation instead of lateral motion. It pivots about a spindle attached to the frame and is provided with an adapter containing three radial bearings so that it can be mounted to swing in an arc the radius of which corresponds to the radius of the microphone stations.

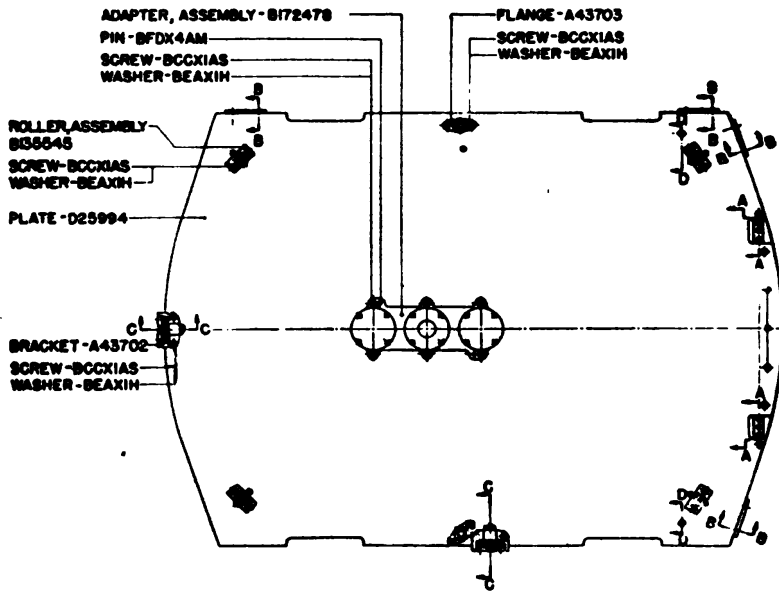
(1) The carriage is supported by four rollers mounted in brackets that are attached to the under side of plate (D25994, fig. 15), providing free movement of the carriage on the tracks.

(2) The adapter assembly (B172478) is attached to the under side of the plate to provide a means of mounting the carriage on the spindle.

(a) The adapter contains three holes in which radial ball bearings are retained. Two of the bearings are retained by disks (A40271, fig. 16) while the bearing that is mounted on the spindle is retained by a retainer (A40270). This retainer is interchanged with one of the disks when a different radius is used. The retainer and disks are secured to the adapter by means of the flathead screws (BCLX3FF).

The disks keep grit and dirt out of the bearings that are not being used.

(b) When the 25-second radius is used, the spindle is inserted in the hole in the frame nearest the bracket and the carriage is mounted, using the bearing nearest the bracket. When changing to the 30-second radius, the retainer (A40270) is interchanged with the disk retaining the second bearing, the spindle is inserted in the middle hole in the frame and the carriage mounted accordingly. When using the 35-second radius, the third hole in the frame and adapter is used.



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FIGURE 15.—Curved-base carriage assembly.

(c) The adapter is fastened to the supporting plate (D25994) by means of six fillister head screws (BCCX1AS) and two pins.

(3) Eight platens (fig. 30) are supplied for use with the curved-base carriage. Two are used with the 25-second radius, three with the 30-second radius, and three with the 35-second radius.

(a) Each platen has five tapered holes accurately located in an arc corresponding to the radii and sub-base lengths as follows:

25-second radius—sub-base length 4.0, 4.5 seconds.

30-second radius—sub-base length 4.0, 4.5, 5.0 seconds.

35-second radius—sub-base length 4.5, 5.0, 5.5 seconds.

(b) The platens are attached to the carriage by means of flathead screws and located by dowel pins. (See figs. 12 and 16.) The dowel pins are riveted to the plate to facilitate locating the platens when changing them.

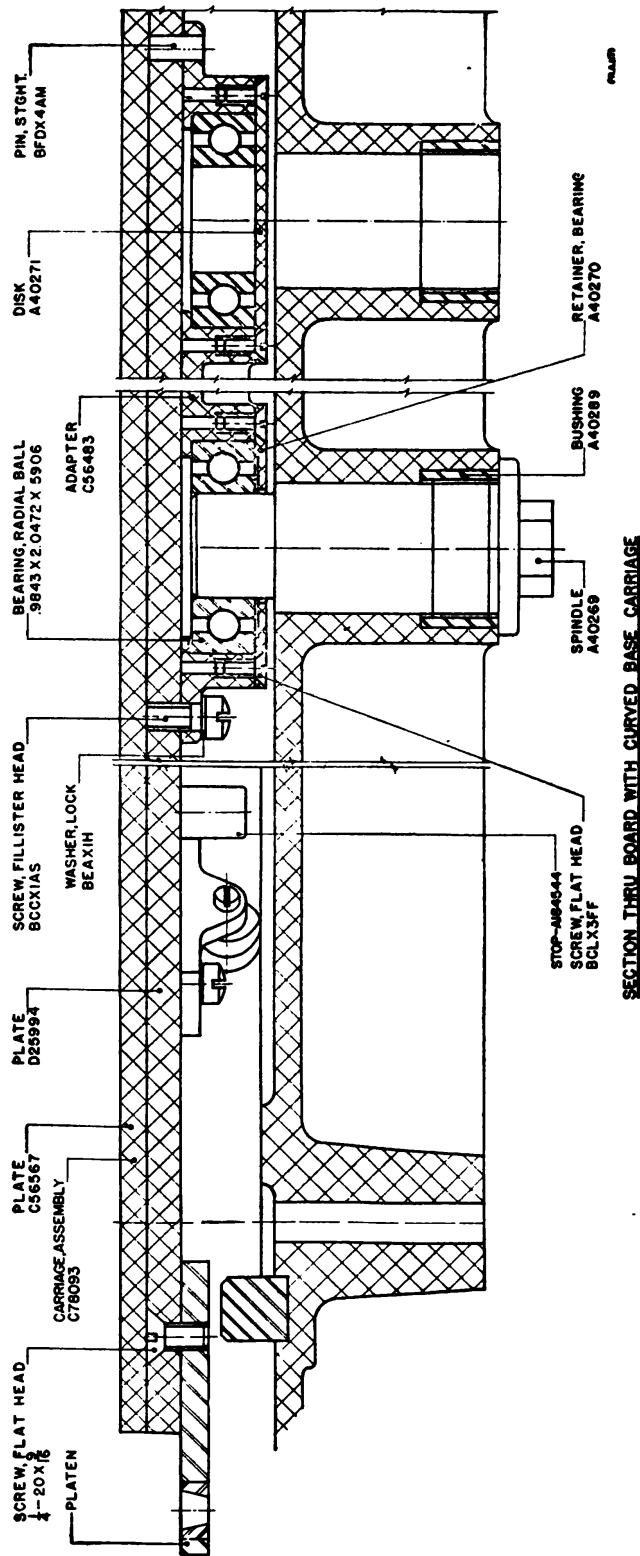


FIGURE 16.—Section through board with curved-base carriage.

(4) The plotting plate (C56567) is clamped to the carriage by the same type of clamping arrangement used on the straight-base carriage.

16. Range arm.—The range arm (fig. 7) pivots about the microphone center assembly on the bracket and can be swung through an angle of 120° , riding on the arc-shaped rail of the frame that contains the time-difference scales. It consists of the range arm, the arm bearing, the support, and the clamping mechanism which is attached to the support.

a. The arm bearing is riveted and pinned to the pivoting end of the arm and is attached to the bracket (D25753, fig. 10) by means of the bearing (A43690) which sits in the hole provided in the bracket. The bearing is spotted in place by the headless cone point screw (BCUX2FE).

b. The other end of the range arm is riveted and pinned to the arm support, which supports the arm and provides the means for rotating it.

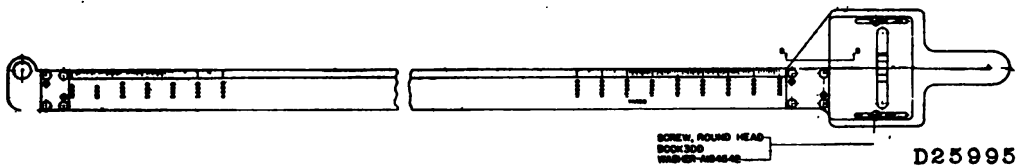


FIGURE 17.—Asymptote range arm assembly.

c. The beveled edge of the range arm is graduated in yards to a scale of $1/20,000$ with a least graduation of 50 yards. It is numbered every 500 yards from 1,000 to 20,000.

d. The vernier assembly (C56346) attached to the range arm was designed to provide a means of drawing short, accurate arcs of long radii without the use of a beam compass, and to permit range readings to the nearest 5 yards. The vernier assembly (fig. 18) is made up of the vernier (B137388), the screw (A48573), and the washer (A30100).

(1) The screw is screwed into the lugs extending from the vernier to provide a means of clamping the vernier to the range arm so that the reading will be accurate and the arc can be drawn with accuracy. The washer (A30100) is inserted on the end of the screw and the screw riveted over to retain it. This is done to keep the screw from working out of the lugs.

(2) The vernier scale is graduated into 10 equal spaces and numbered every other space from 10 to 50. The 10 spaces are equal to 9 spaces on the range arm scale providing for a least reading of 5 yards when the vernier registers opposite the range scale.

e. (1) The arm support rests on the arc-shaped rail. It contains a wire index and a clamping mechanism. The index wire (A40273) is

secured in the frame (A40272) by the screws (BCUX1EE) and can be adjusted in order to orient the beveled edge of the range arm. (See fig. 19.)

(2) An adjustable cover (A40279) attached to the support provides a means of covering up all scales but the one being used at the time.

f. The clamping mechanism attached to the support is so designed that by pressing the lever (fig. 27) the clamp is released and the arm can be rotated to the desired reading. When the lever is released the spring forces the lever back to its normal position, clamping the support to the rail.

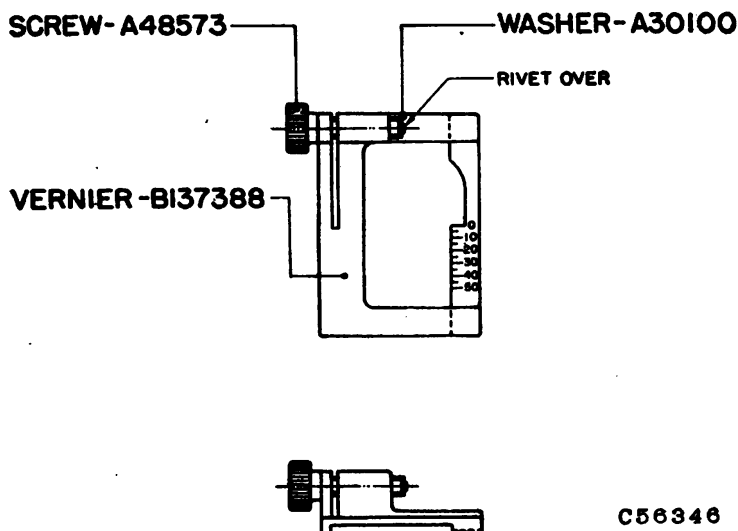


FIGURE 18.—Vernier assembly.

(1) The mechanism (sec. F-F, fig. 19) is made up of the link (A40275) which rotates on the pivot (A40277); the clamping shoe (A40274) which is pinned to the link; and the crank (A40276) which is pinned to the lever.

(2) When the lever is pressed against the arm of the support it turns the crank, lowering the end of the link enough to release the clamping action between the shoe and the under side of the rail. The pivot (A40277) is retained by the collar (A35928) which is pinned to the outside end of it.

g. The pivot bearing (A43690, sec. D-D, fig. 10) contains the microphone center point mechanism which is used to locate the midpoint between microphone stations on the plotting paper by punching a hole in the paper.

(1) The pin (A43705) is welded to the special screw (A40728) which is screwed into the plunger (A43708). The button (A40727) is locked to the top of the plunger by two cone point screws

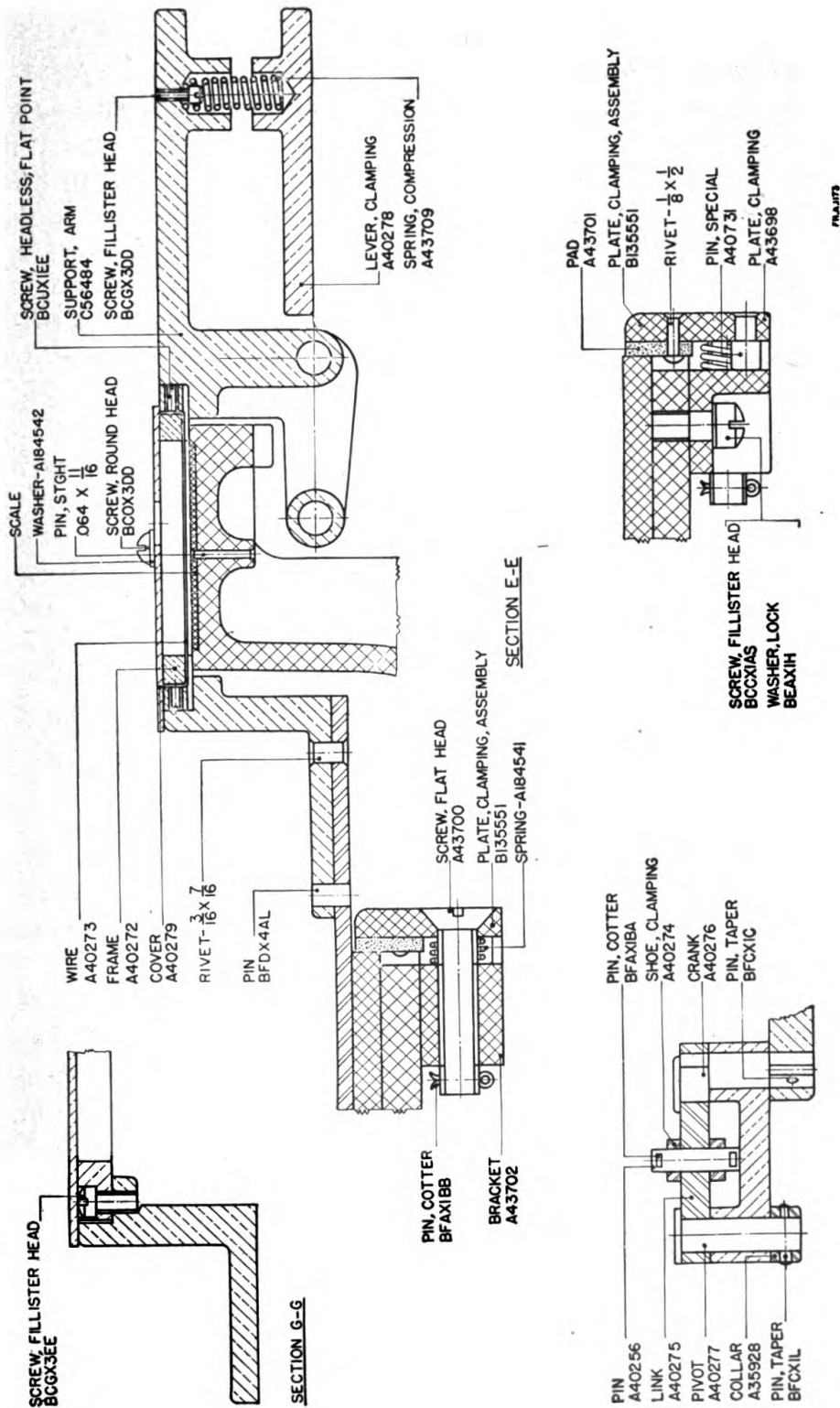


FIGURE 19.—Sound ranging plotting board M1, sectional views.

(BCUX2BB). The pin can be adjusted so that just enough of the point will protrude from the plunger to prick the plotting paper on the board.

(2) The plunger is retained in the bearing by the spring (A33151) and the retaining ring (A40730). When the carriage is located in a position corresponding to one of the midpoints, a light tap on the button will force the plunger down in the bearing, causing the pin to prick a point in the map indicating the plotted position of that midpoint. The spring will force the plunger back to its normal position.

17. Component parts.—*a.* For the purpose of having a fairly simple and yet accurate method of computing the corrections that have to be applied to the time intervals in order to make a corrected plot, the following correction devices have been designed:

(1) A temperature correction chart (fig. 20) for all sub-bases.

(2) Asymptote correction charts (figs. 21, 33, 34, and 35) for each of the 4.0, 4.5, 5.0, and 5.5 sound-second sub-bases.

(3) A mechanical device, the sound ranging wind corrector M1 (fig. 31), has been designed for the purpose of determining the wind correction mechanically.

b. Temperature correction chart.—(1) Only one temperature-correction chart is needed regardless of the length of the sub-bases used. This chart has three scales printed on it in such positions that a straightedge placed across it coinciding with a variable on any two of the scales will determine the corresponding third variable.

(2) The time-difference scale, in seconds, is located on the left side of the chart and the scale for corrections, in seconds, is printed on the right side of the chart. The air temperature scale runs diagonally across the chart intersecting the correction scale at zero seconds and 50° F.

(3) The correction scale is graduated in two directions, from zero upward corresponding to temperatures over 50° F. in which the correction takes the same sign as the time difference, and from zero downward in which the correction takes the opposite sign from the time difference.

(4) The temperature scale is graduated from 15° to 120°.

(5) The time-difference scale is graduated from 0 to 2.2 seconds. To find the correction for time differences greater than 2.2 seconds at any temperature: Find the correction for one-half the time difference and multiply it by 2, or one-third and multiply it by 3, etc. The correction is proportional to the time difference at any temperature.

(6) The center of the sheet is a plate of white vinylite (a plastic) with a matte surface. After the scales are printed on the sheet, a

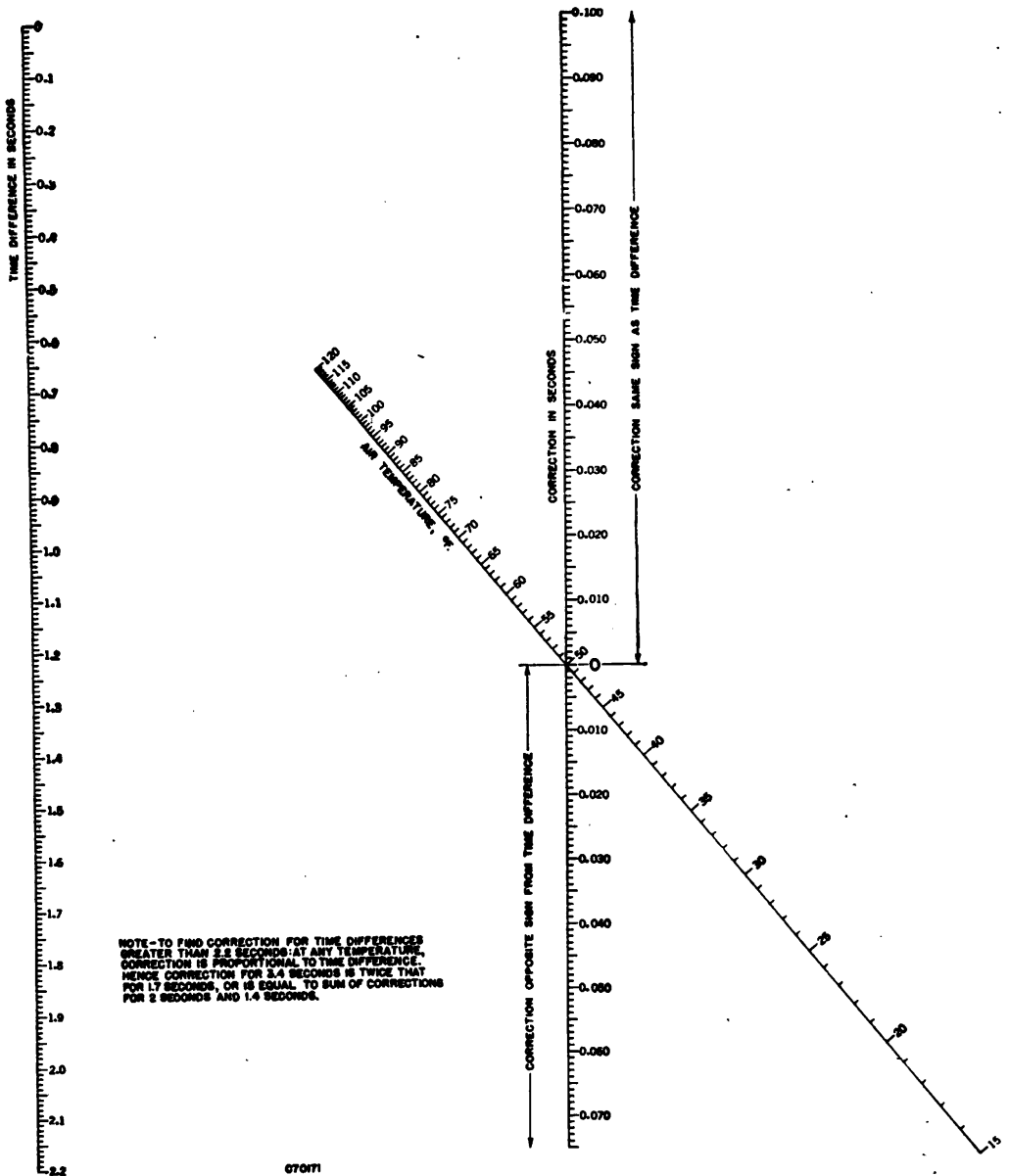


FIGURE 20.—Temperature correction chart for all sub-bases.

layer of transparent vinylite (0.005 thick) is applied to both sides to protect the printed scales.

c. Asymptote correction charts.—(1) There are four asymptote correction charts furnished with the plotting board, one for each standard sub-base length. (See figs. 21, 33, 34, and 35.) Actually there are only two charts but the nomographs are printed on both sides of each chart.

(2) The charts are all similar in design but the time-difference and time-correction scales on each one are graduated to different limits. The time-difference scales are located on the left side of the chart and the correction scale is on the right side of the chart, while the range scale in yards runs diagonally across the chart, intersecting the correction scale at the zero graduation.

(3) The time-difference scale is graduated in seconds from 0 to 4.0 for the 4.0-second sub-base, to 4.5 for the 4.5-second sub-base, to 5.0 for the 5.0-second sub-base, etc. The range scale on each chart runs from 1,000 yards to 30,000 with ∞ representing the intersection with the correction scale at zero. The correction scale runs from zero upward, the maximum graduation differing on each chart.

(4) These charts are of the same material and construction as the temperature correction charts.

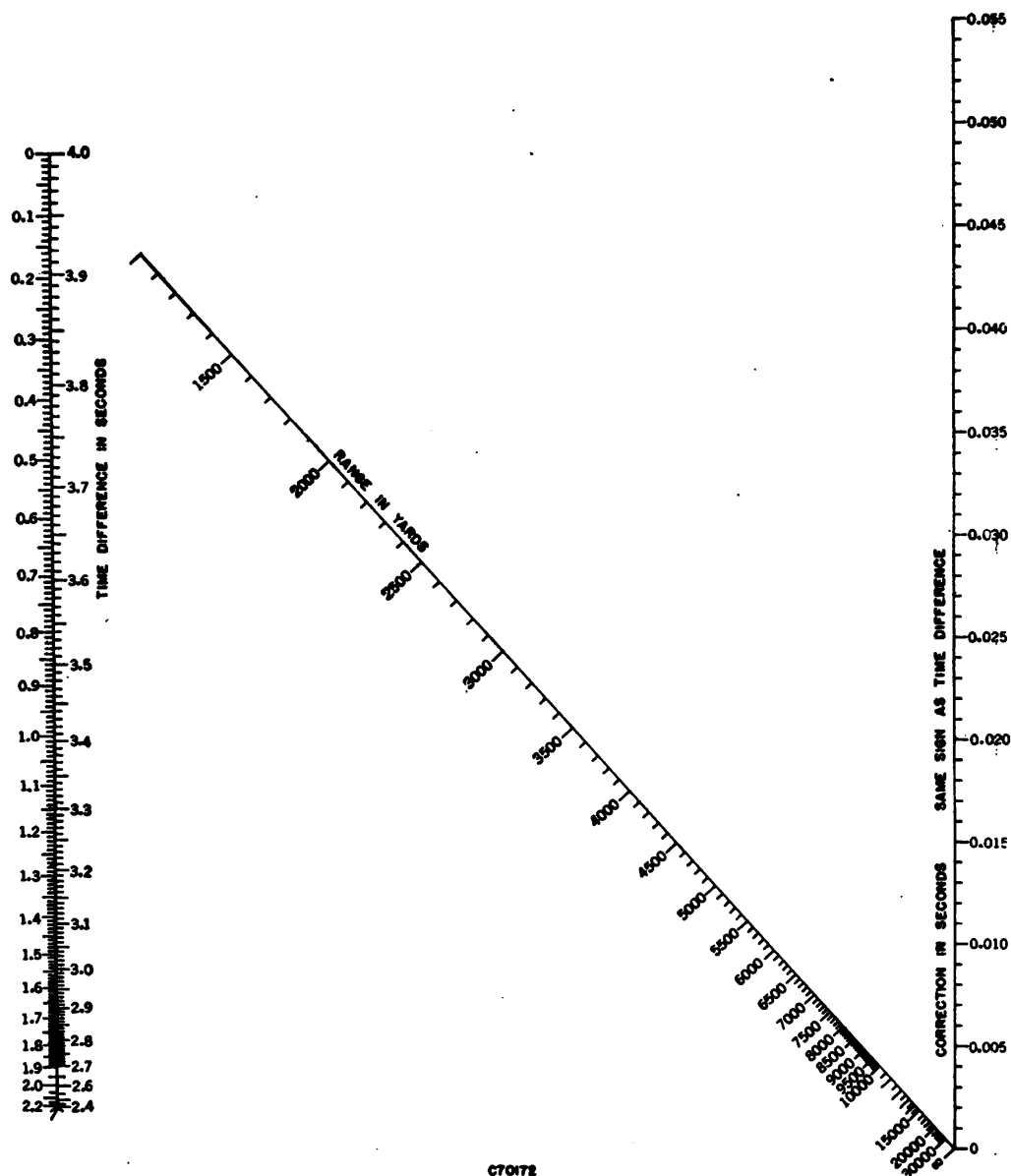
d. Sound-ranging wind corrector M1.—(1) The wind corrector M1 solves the wind correction equation graphically, and the time-difference correction can be read from it both in value and sign.

(2) It consists principally of a central disk (C44887, fig. 22), the correction scale (C44885), which is screwed to the disk, the azimuth scale or ring (C44886), which is clamped between the correction scale and the disk and is free to rotate about the disk, and the wind arm.

(3) The correction scale is a circular plate with horizontal lines engraved thereon to represent time corrections in seconds. Each line represents 0.005 of a second and every alternate line is numbered, representing 0.010 of a second. The graduations read from the center in both directions, allowing for a maximum reading of 0.195 with zero at the center. Three rows of figures are engraved on the plate to facilitate the reading of the corrections from any part of the circle.

(4) The azimuth ring contains two scales: the inner scale or azimuth scale to indicate the azimuth of the sub-base, and the outer scale or wind-direction scale for setting off the azimuth of the wind.

(a) The inner scale is graduated in mils providing for a least reading of 50 mils and is numbered every other graduation from 0 to 6,300. The outer scale is graduated in degrees, provides for a



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FIGURE 21.—Asymptote correction chart, 4-second sub-base.

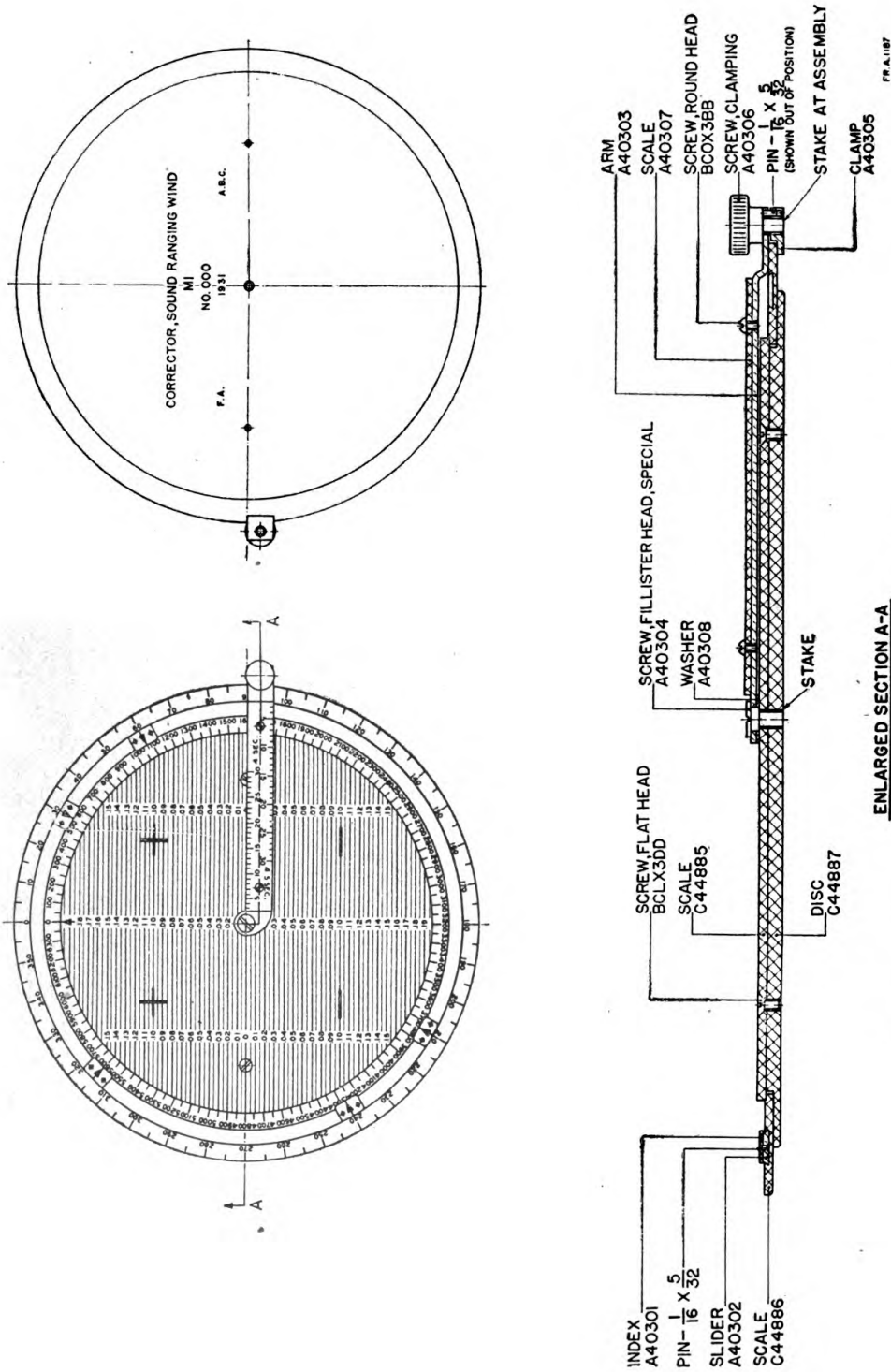


FIGURE 22.—Sound ranging wind corrector M1, assembled views.

least reading of 5° , and is numbered every other graduation from 0 to 350.

(b) The ring contains a circular dovetailed groove in which the sub-base markers fit. These markers are free to slide in this groove and can be placed at a position corresponding to the azimuth of the sub-base as directed from M_2 to M_1 , M_3 to M_2 , etc.

(5) The wind arm consists of the arm (A40303, fig. 22) which pivots about the special screw (A40304); the scale (A40307) which is fastened to the arm; and a clamping screw and clamp. The clamping screw (A40306) acts as a handle to facilitate rotating the arm, while the clamp (A40305) prevents the arm from riding off the ring.

(a) Two scales are provided for use with the arm. Each scale has two sets of graduations engraved on it representing the wind velocity for the respective sub-base lengths. One scale has the graduations for 4.0- and 4.5-second sub-bases, while the other has the graduations for the 5.0- and 5.5-second sub-bases.

(b) The scales are graduated into 32 equal divisions representing the wind velocity in miles per hour and providing for a least reading of 3 miles per hour. They are numbered from 5 to 30, every fifth division.

(c) The wind corrector M1 is not packed or stored within the packing or accessory chest of the plotting board but is provided with a packing chest of its own (fig. 32). It should be stored in this when not in use or when being transported.

18. Accessories.—Each instrument is supplied with a packing chest, an accessory chest, a weatherproof cover, two screw drivers, and a socket wrench.

a. The packing chest (fig. 29) is used for storing the frame, one of the carriages, the legs, the brace, the range arm, and the tools, while the accessory chest (fig. 30) is used to store the extra platens, the carriage (not in use), the cover, and the four plotting plates.

b. The range arm is placed in a support provided in the packing chest, and the tools are kept in a small compartment within the chest. The accessory chest is constructed so that the platens and other parts can be kept therein without becoming damaged or broken.

c. A small compartment is also provided in the packing chest for the storage of the correction charts.

SECTION VI

ADJUSTMENT

Method	Paragraph 19
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19. Method.—The wire index contained in the range arm support and the microphone center point are the only parts that should require any adjustments.

a. To adjust the wire index remove the cover (A40279, fig. 19), loosen the screws (BCGX3EE, sec. G-G) that secure the frame (A40272) to the support, and then adjust the frame until the wire index is in line with the beveled edge of the range arm. After making the adjustment, tighten the screws and replace the cover.

b. To adjust the microphone center point to secure desired size of prick punch hole, remove the button by loosening the two small headless screws on its sides and then, by means of a small screw driver, thread the adjustable pin in or out as required. After securing the desired adjustment, replace the button on the plunger and tighten the screws.

SECTION VII

CARE AND PRESERVATION

Handling	Paragraph 20
Lubrication	21
Storage and transportation	22

20. Handling.—The sound ranging plotting board M1 is not an unusually delicate instrument, but care should be exercised in handling it so as not to dent or chip the beveled edge of the range arm or the surface of the plotting plates. The following precautions should be exercised when setting up or operating the plotting board:

a. Fasten the legs securely in the sockets provided in the under side of the frame. Tighten bolts.

b. The brace should be evenly located and firmly clamped to the legs, so that the board will not collapse while plotting on it. Tighten thumbscrews provided.

c. When changing platens tighten securely the screws fastening the plates to the carriage plate.

d. Clamp the plotting plate securely to the carriage. Tighten screws on clamping plate.

e. When using the straight-base carriage—

(1) The guide rail should be firmly secured to the frame. Tighten nuts. (BBAX1A, fig. 9).

(2) The brackets containing the rollers should be fastened tightly so as not to produce any wobbly motion of the carriage along the rail.

(3) The spindle should be removed from the frame and placed in the chest provided for it, as it might interfere with the movement of the carriage.

f. When using the curved-base carriage—

(1) The spindle should be firmly secured in the frame.

(2) The adapter, containing the ball bearings, should be attached securely to the carriage plate.

(3) The carriage should be mounted in the bearing corresponding to the base radius being used for the particular plot.

(4) The retaining ring holding the bearing in place should be fastened securely to the adapter. Tighten screws (BCLX3FF, fig. 16).

(5) The disks (A40271) retaining the other two bearings should be replaced and tightened when a change is made in the radius, thus requiring a change in mounting.

g. When using the locating mechanism to change the position of the carriage—

(1) Do not jam the locking lever down. Feel the plunger into place and lower the lever with an easy motion.

(2) The lever should be all the way down and the carriage locked before attempting to plot on the board.

h. The pivot bracket should be tightened snugly against the frame after changing a carriage. Tighten bolts (A40258, fig. 10).

i. The pivot bearing (A43690) should be locked in the bracket. Tighten screw (BCUX2FE, sec. B-B, fig. 10).

j. Do not attempt to swing the range arm without releasing the clamp. Press clamping lever.

k. Before plotting, the opening in the cover should be set over the particular time-difference scale to be used.

l. When moving the plotting board, the clamping screws locking the carriage to the frame should be tightened. Turn wing knob (A40263, fig. 9).

m. When tightening the various screws and knobs, exercise care that they are tightened just enough to insure a snug fit as too much pressure might damage the threads or injure the platen, plates, etc.

n. Special care should be exercised in the handling of the platens because any damage affecting the positioning or shape of the tapered holes will impair the accuracy of the plotting board.

o. Special attention should also be paid to the care of the bearing surfaces of the guide rail.

p. Special care should be given to the handling of the correction charts as these charts are made of an inflammable material.

21. Lubrication.—*a.* The roller paths, rail, and platens should be covered with a light covering of oil to prevent corrosion.

b. The bearing surfaces and hinge pins in the locating mechanism should be oiled occasionally to insure easy working of the levers.

c. Be sure that no oil gets on the range arm, the plotting surface, or the time-difference scale.

d. To prevent the collection of dust and grit, wipe off any excess grease or oil that might seep from the mechanisms or bearings.

e. Oil, lubricating, for aircraft instruments and machine guns is the only lubricant and rust preventive to be used on this matériel.

22. Storage and transportation.—A packing chest (fig. 29) and an accessory chest (fig. 30) are provided for the storage and transportation of the instrument.

a. When placing the instrument in the packing chest, remove the range arm from the frame and place it in the supports provided. Place the vinylite correction charts in the compartment provided and close the door of the compartment. Place the legs and brace in their respective spaces in the lower portion of the chest, then place the frame in position as shown in the chest (fig. 29). One of the carriages should remain clamped to the frame when stored in place. Place the tools in the tool compartment provided. By arranging the parts in this manner the lid will close easily without damaging any of the parts.

b. The other carriage should be clamped in the space provided on the inside of the lid of the accessory chest.

c. The plotting plate should be removed from the carriage and placed in the accessory chest. The extra plates should always be stored in the racks provided in this chest. Racks are also provided in this chest for the storage of the extra platens. The platens that are not being used should always be kept in the racks provided.

d. The spindle should be kept in the compartment provided for it when not being used.

e. The instrument should always be stored in a dry place. If it is exposed to wet weather, the parts should be thoroughly dried and wiped off before being placed in the chests for storage or transportation.

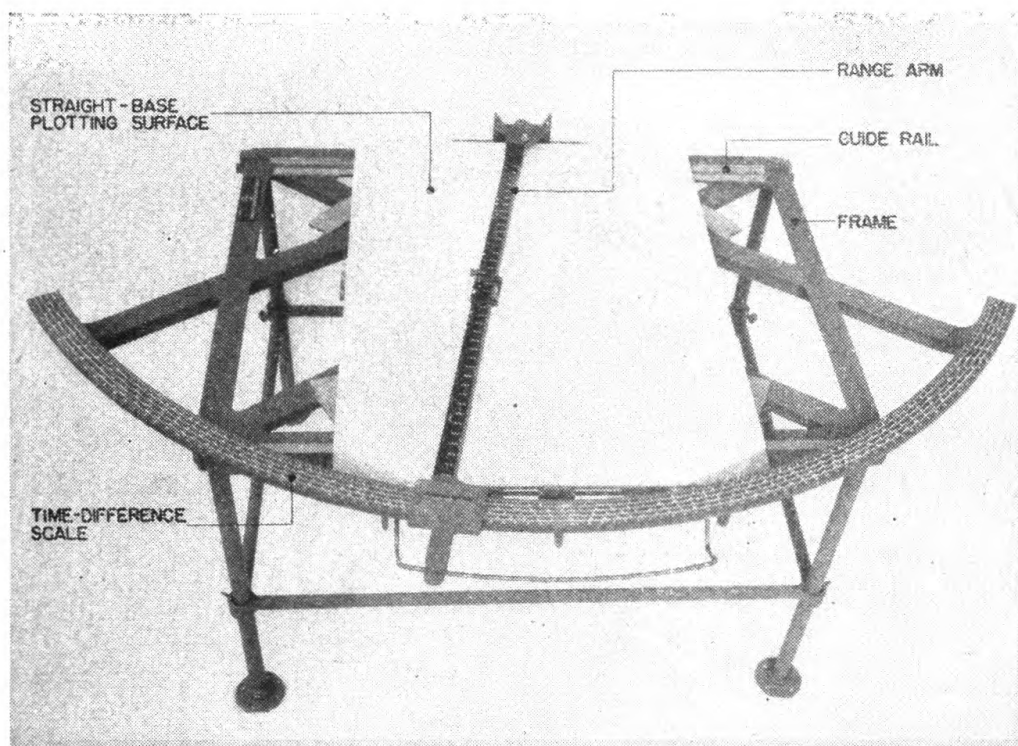


FIGURE 23.—Sound ranging plotting board M1, straight-base carriage.

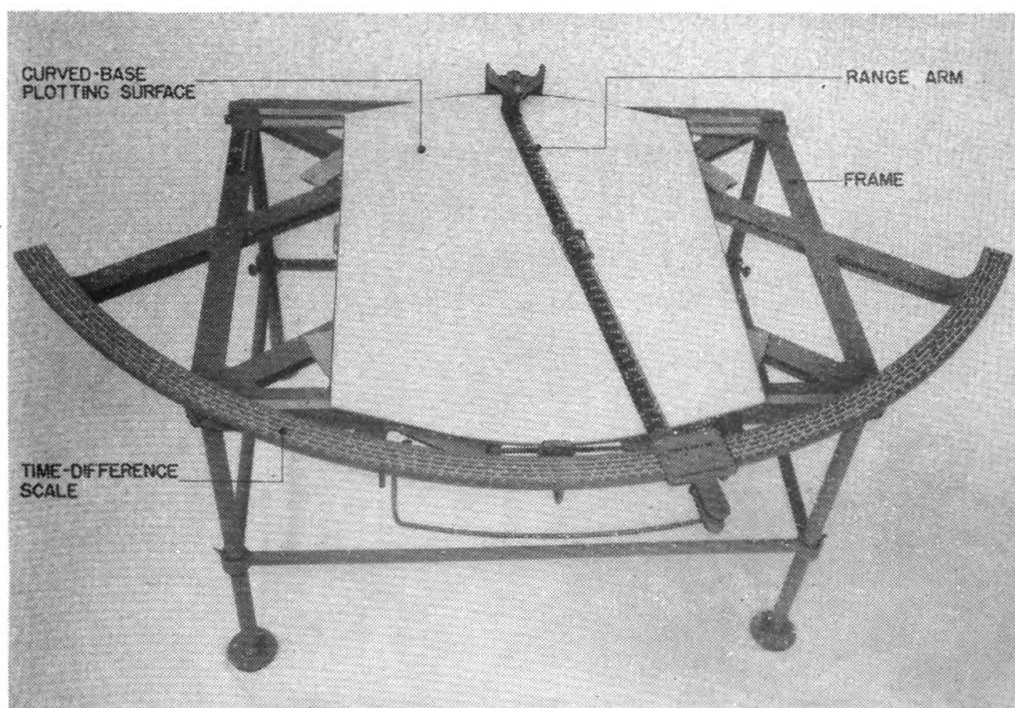


FIGURE 24.—Sound ranging plotting board M1, curved-base carriage.

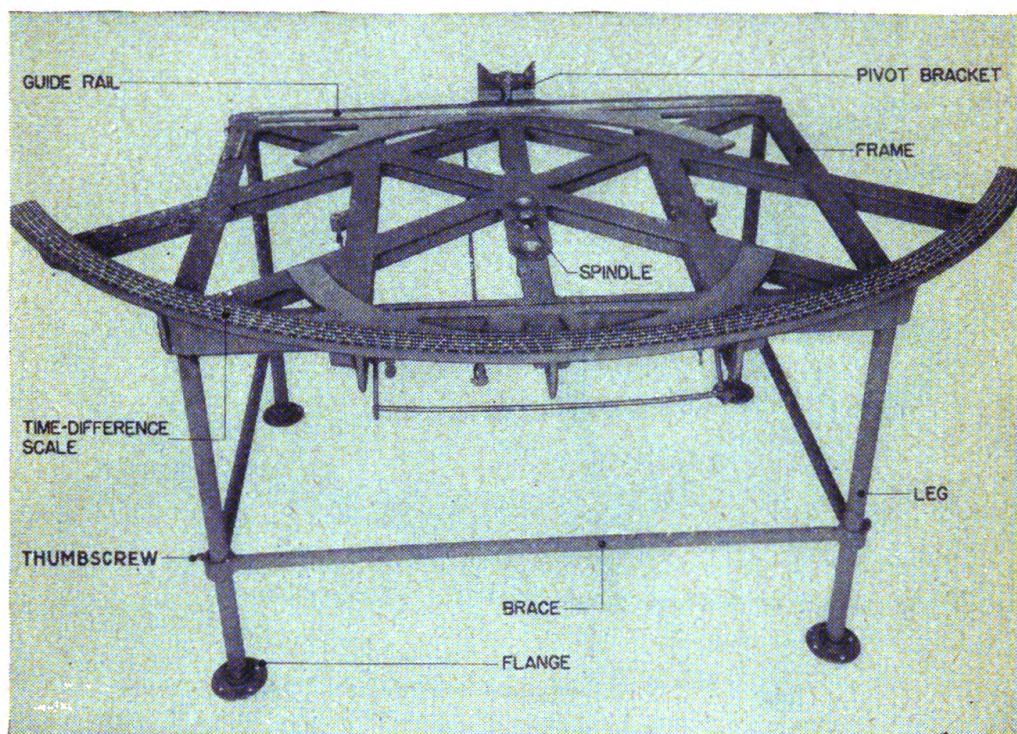


FIGURE 25.—Sound ranging plotting board M1, carriage removed.

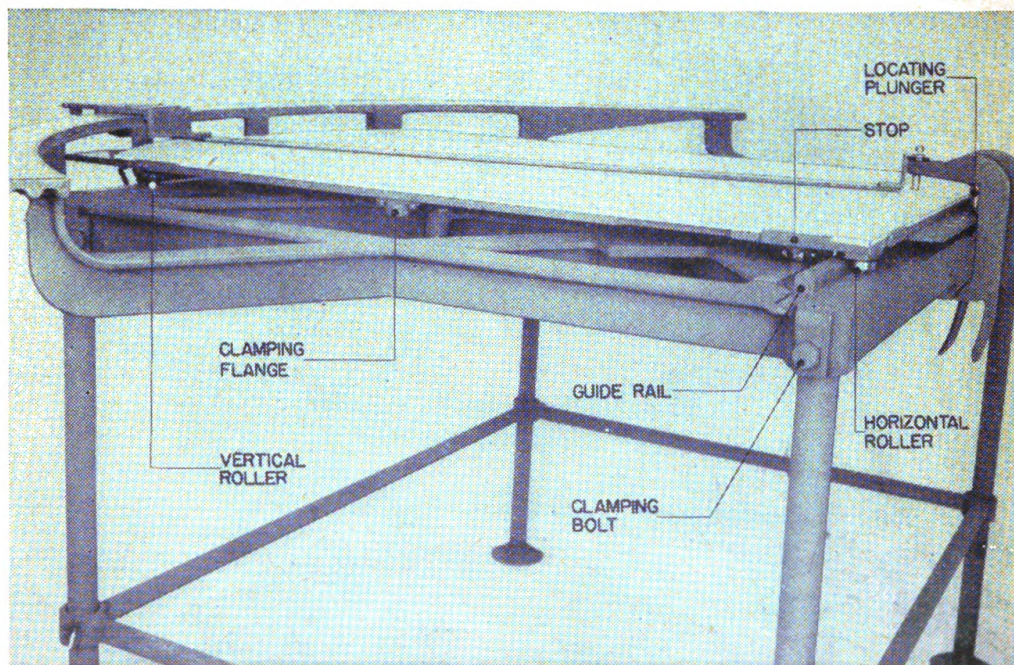


FIGURE 26.—Sound ranging plotting board M1, side view.

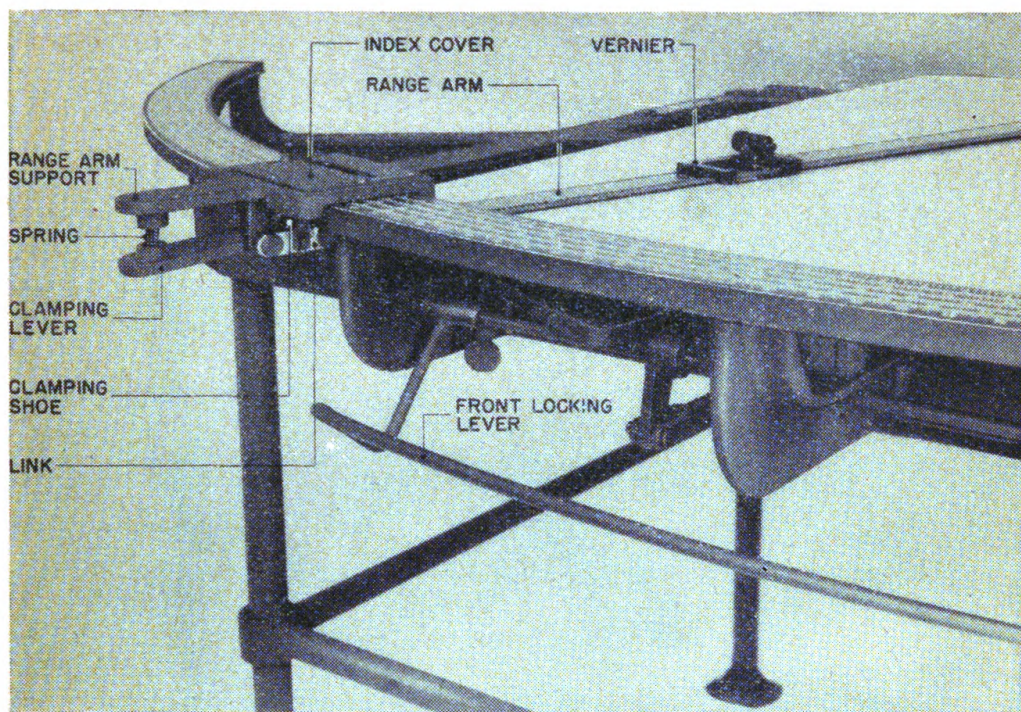


FIGURE 27.—Sound ranging plotting board M1, clamping mechanism.

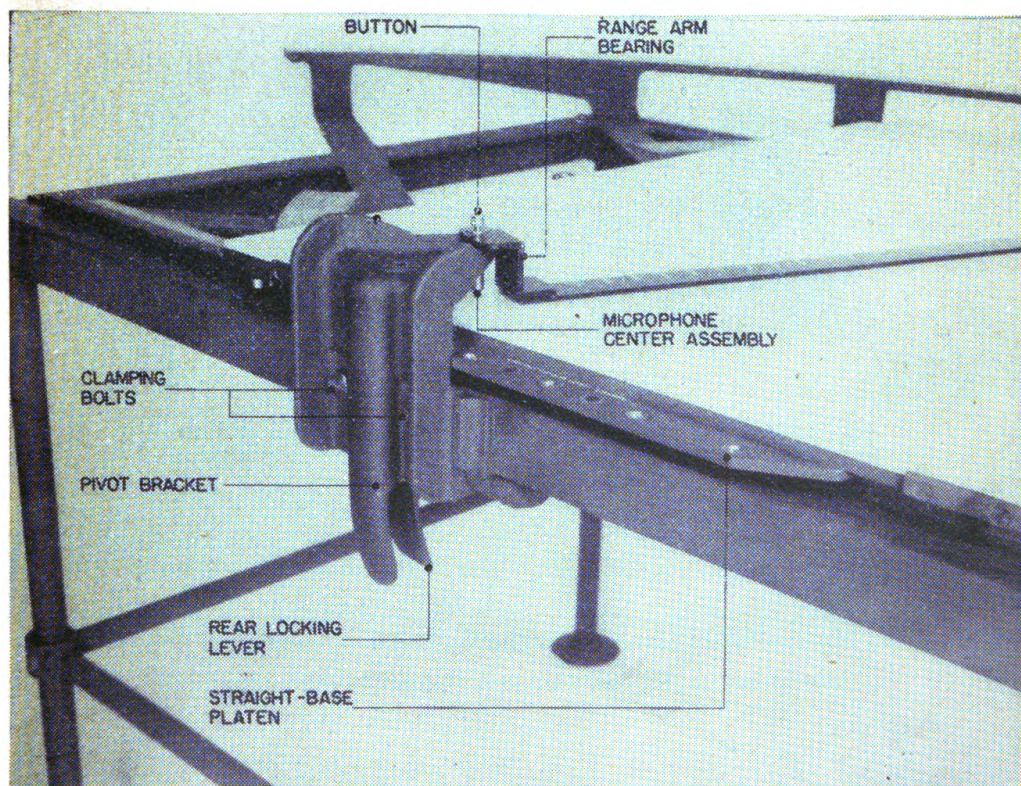


FIGURE 28.—Sound ranging plotting board M1, rear view.

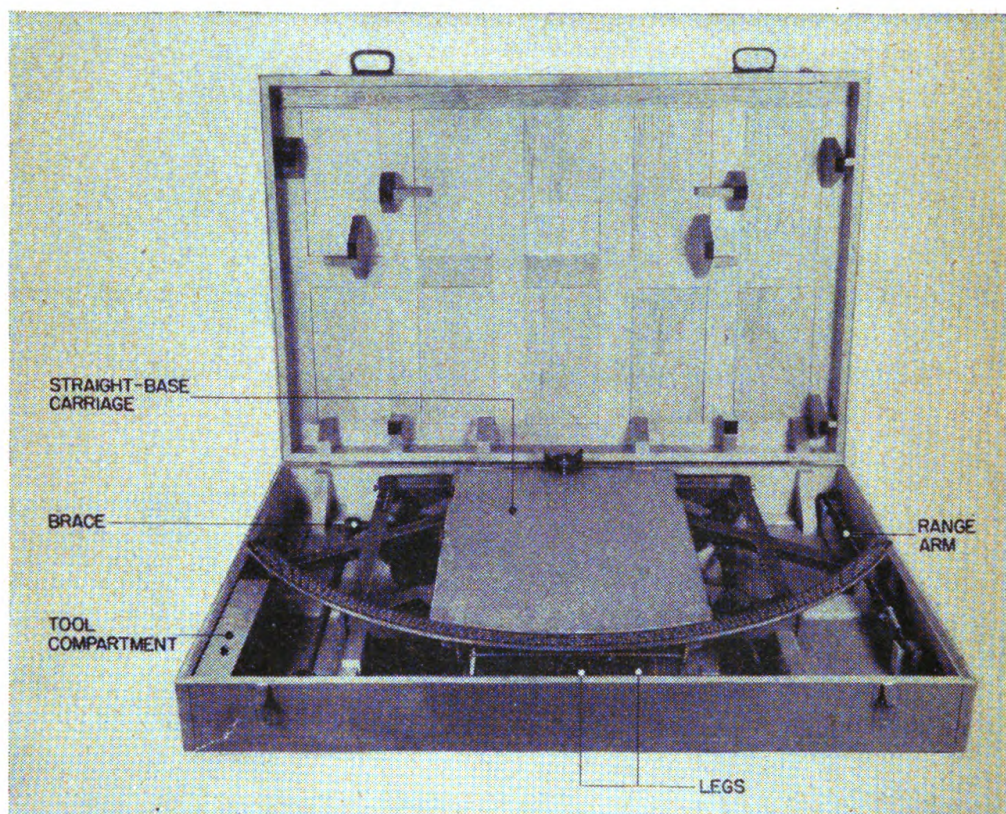


FIGURE 29.—Sound ranging plotting board M1, in packing chest.

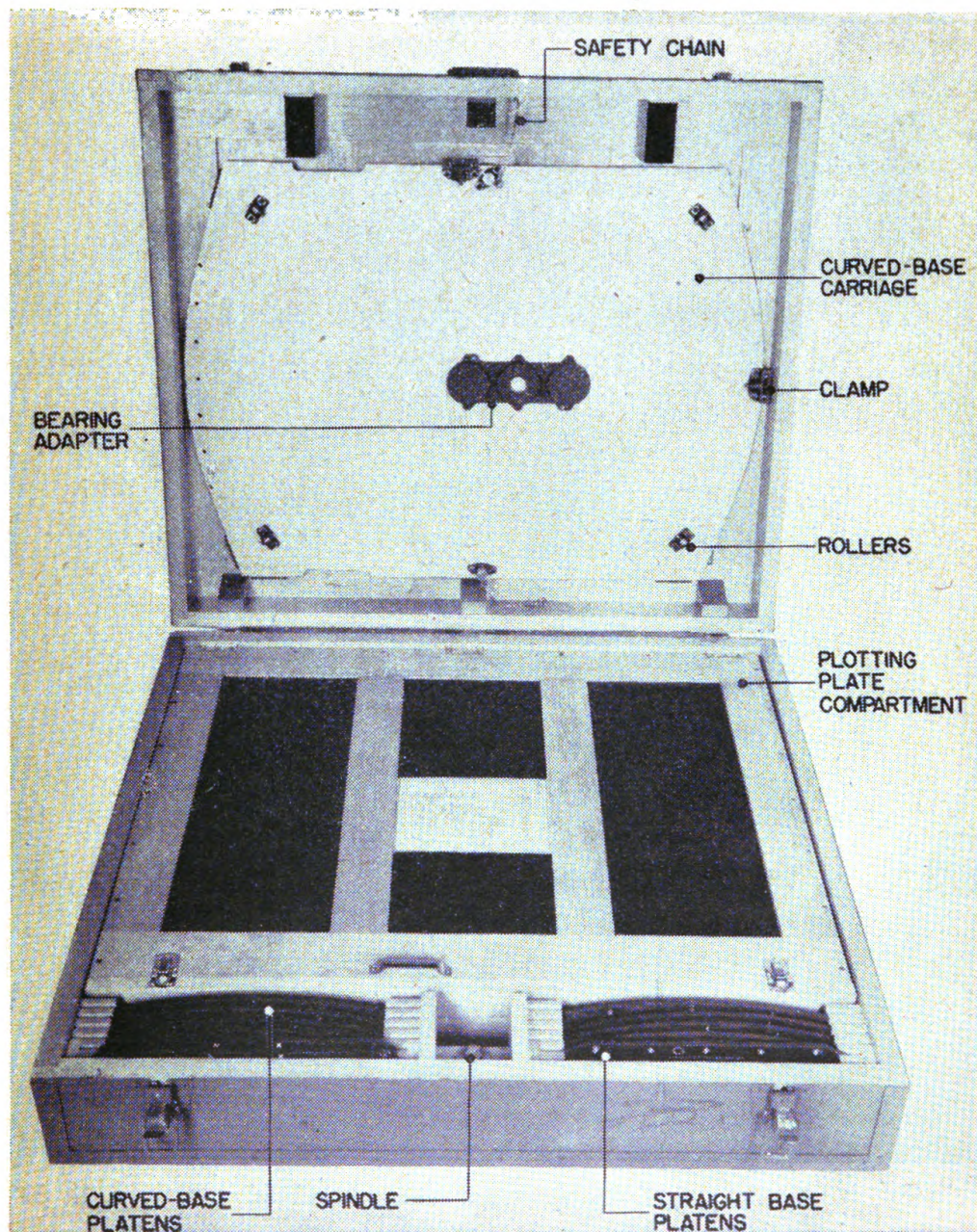


FIGURE 30.—Sound ranging plotting board M1, accessory chest.

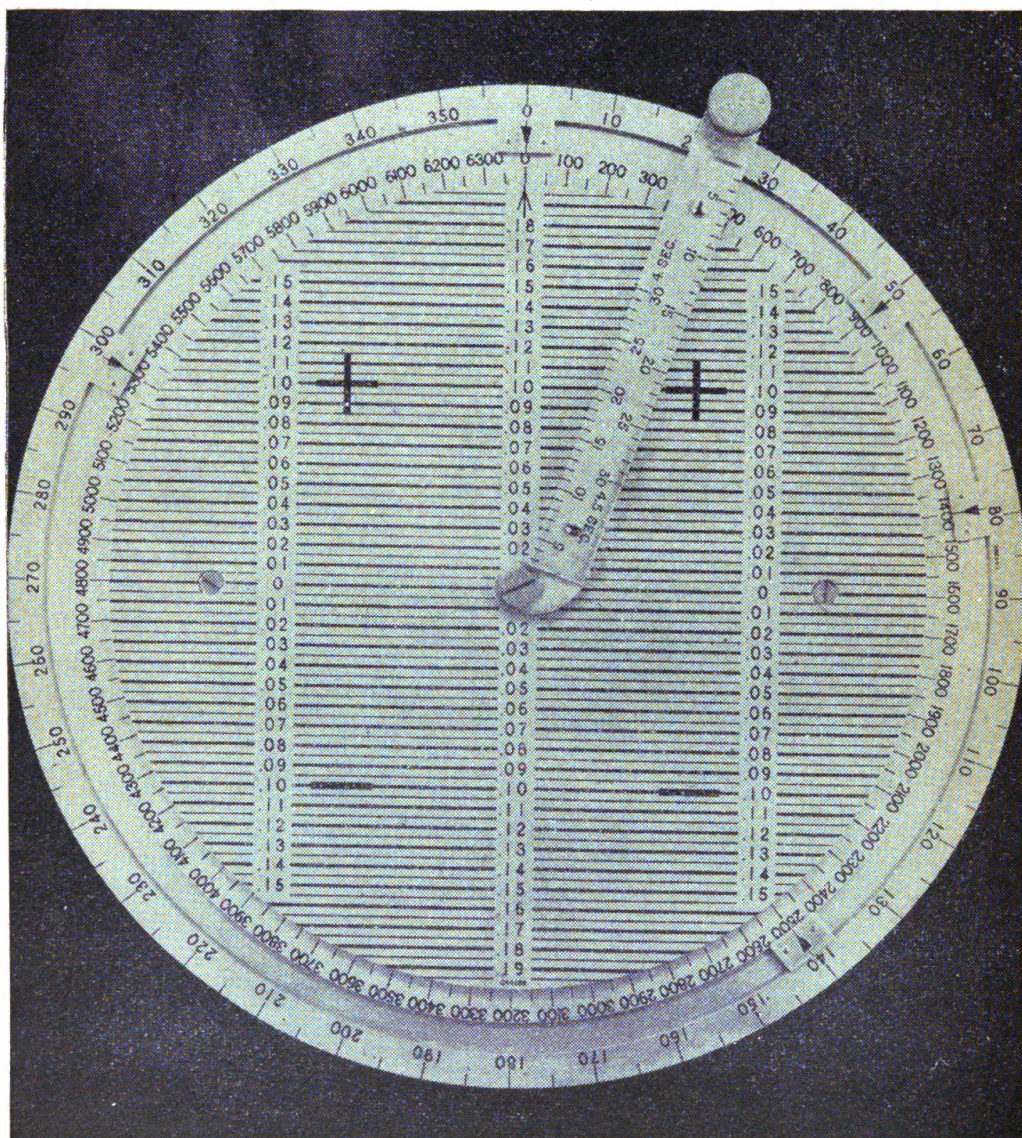


FIGURE 31.—Sound ranging wind corrector M1.

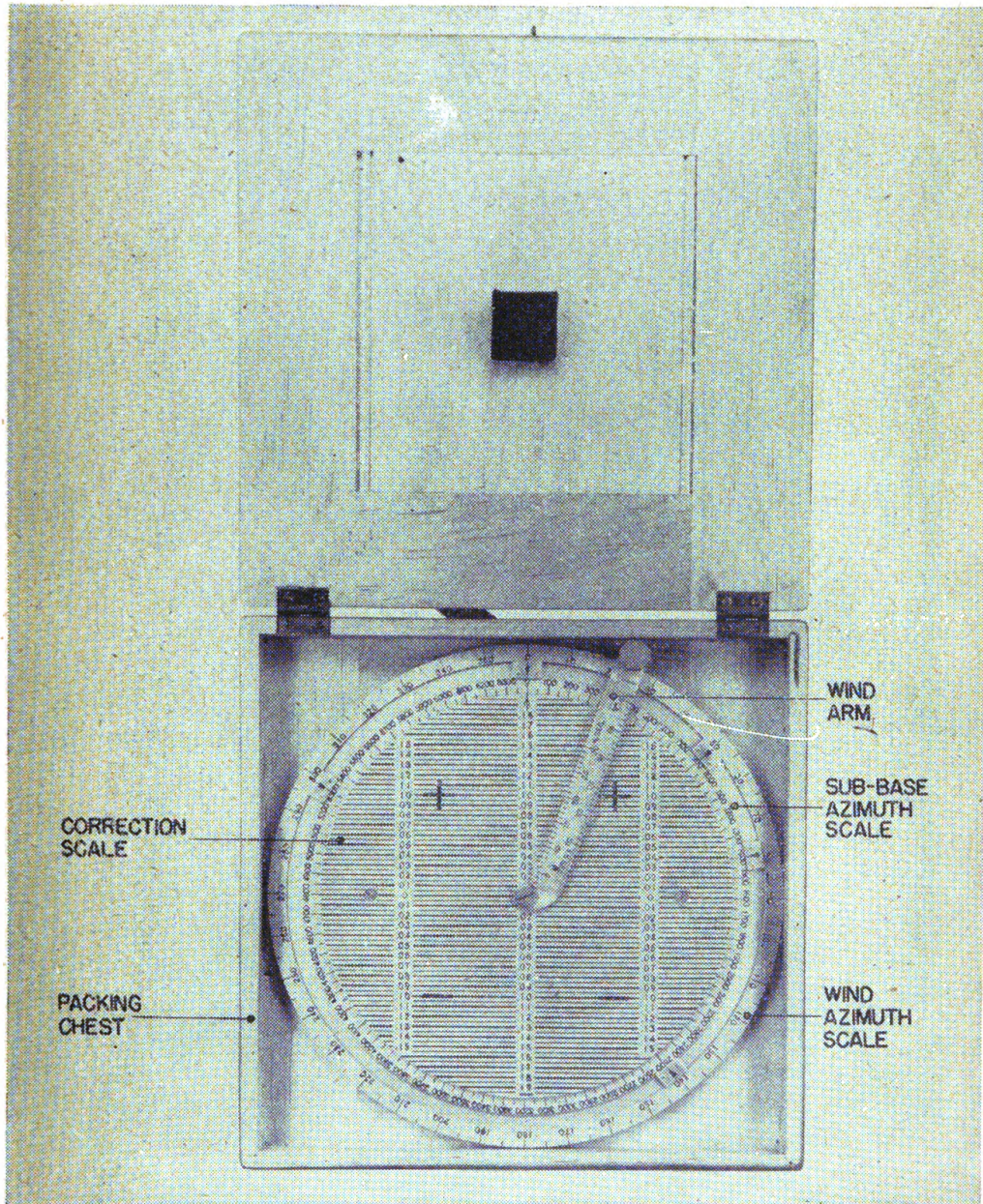


FIGURE 32.—Sound ranging wind corrector M1, in packing chest.

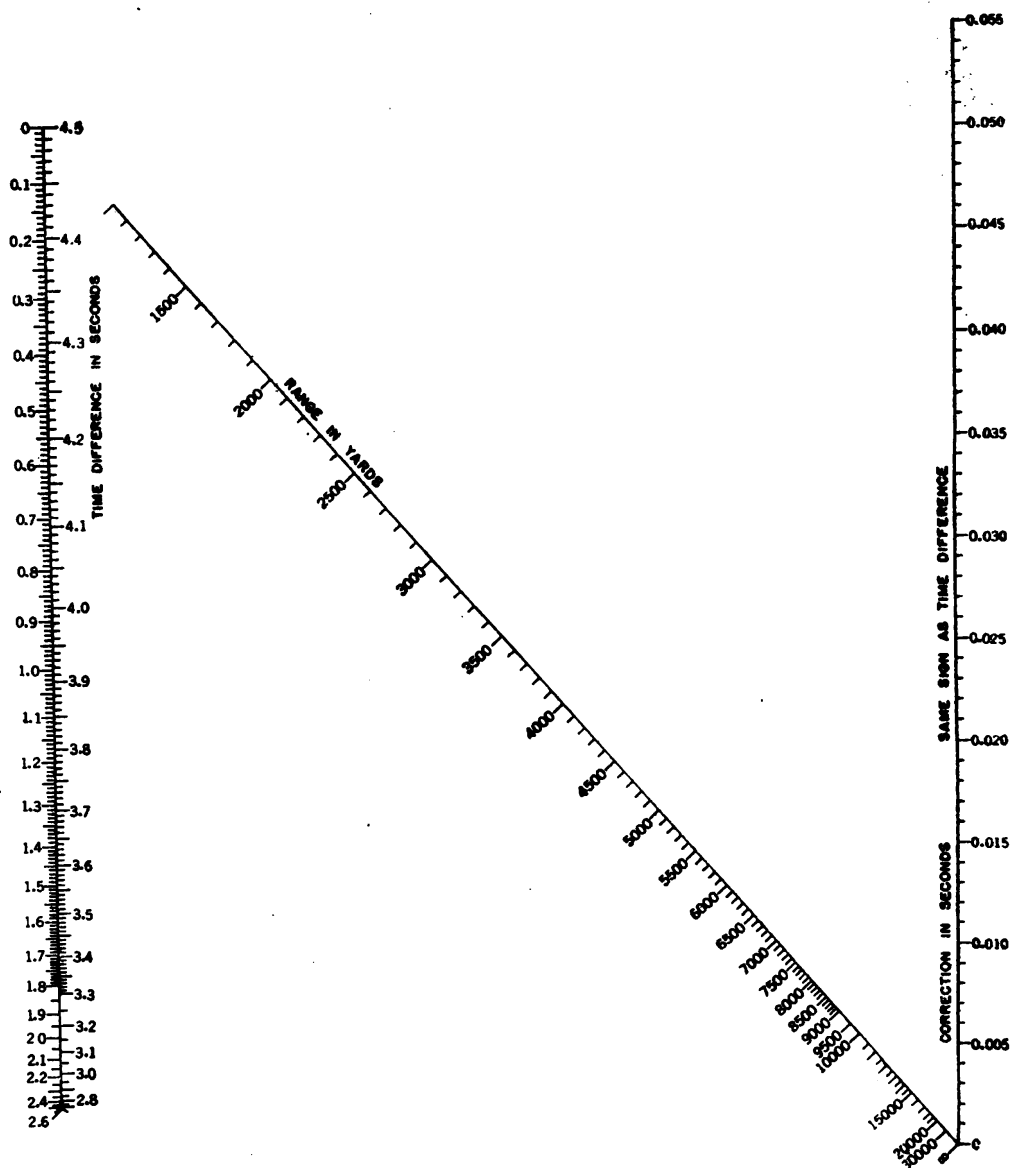


FIGURE 33.—Asymptote correction chart, $4\frac{1}{2}$ -second sub-base.

APPENDIX

LIST OF REFERENCES

1. Standard nomenclature lists.

Board, sound ranging plotting, M1----- SNL F-154
Corrector, sound ranging wind, M1----- SNL F-153
Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publications for Supply Index"----- (OPSI)

2. Manuals.

The observation battalion----- FM 6-120
Cleaning and preserving materials----- TM 9-850

[A. G. 062.11 (7-25-41).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

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(For explanation of symbols see FM 21-6.)

